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# TECHNICAL APPENDICES

FOR

THE DEVELOPMENT OF A TEST  
FOR SELECTING RESEARCH PERSONNEL



AMERICAN INSTITUTE FOR RESEARCH  
PITTSBURGH, PENNSYLVANIA

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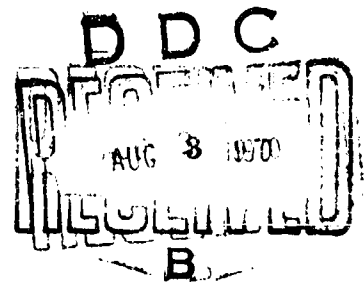
TECHNICAL APPENDICES

FOR

THE DEVELOPMENT OF A TEST  
FOR SELECTING RESEARCH PERSONNEL

Appendices for a report prepared  
under the sponsorship of the

Manpower Branch  
Human Resources Division  
Office of Naval Research



January, 1950

AMERICAN INSTITUTE FOR RESEARCH

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Explanations of the contents of each appendix appear on the corresponding title pages, which precede the page numbers listed here.

## Appendix I

### PROJECT MEMORANDA

Appendix I includes the following materials:

- A. Memorandum for Item-Writers, containing information and instructions prepared for the individuals who constructed test items
- B. Memorandum for Test Critics, containing information, instructions, and illustrative material for persons professionally engaged in scientific work who were asked to criticize test items
- C. Memorandum for Editorial Reviewer, containing explanation of materials and instructions for the editorial critic who was asked to review final tryout forms of the test
- D. Memorandum for Rationale Reviewers, containing explanation of materials and instructions for critics who were asked to review the rationales prepared for each item as well as the items themselves

21 April 1949

PROJECT FOR THE DEVELOPMENT OF SELECTION INSTRUMENTS  
TO MEASURE APTITUDES FOR SCIENTIFIC WORK

MEMORANDUM FOR ITEM-WRITERS

Introduction

The present test development project sponsored by the Office of Naval Research, is a continuation study undertaken upon completion of an earlier project resulting in the determination of the critical requirements for scientific personnel. The enclosed list of critical requirements is the outcome of that study, and will serve as the basic data for the present project.

The objective of the present research is the development of selection instruments to measure aptitudes for scientific work. Specifically, it is intended to develop test items to predict the critical requirements identified earlier. Since the methodology of the test development project rests to a great extent upon that of the preceding study, a summary of the procedures followed in determining the critical requirements is given below.

Determination of the Critical Requirements

The critical requirements are based on detailed descriptions of observed on-the-job behaviors which were judged by the observer as particularly effective or ineffective. Five hundred senior research and engineering personnel in the major Naval scientific laboratories were interviewed and asked to describe incidents illustrating job behaviors which they considered particularly effective or ineffective. The interviewing sample represented roughly 10% of the total population of Civil Service professional grades 4 and above in Navy laboratories. The various job-

title groups were sampled in proportion to their numbers in the population, and included most of the physical science and engineering groups; biological and social science were not included. All scientific and engineering functions were represented by the jobs of persons interviewed, from basic and applied research to design, development, testing, and production engineering.

Over 3,000 critical behaviors were described in the incidents obtained. The behaviors were then classified and formulated into a list of critical requirements through grouping of closely similar and related behaviors. The final formulation consists of eight major areas, each containing a number of sub-areas. The organization of the behavior groupings was developed primarily by considering the sequences and functions in scientific and engineering work.

#### Rationale of the Test Development Project

As was stated above, the project objective is the development of test items for the enclosed list of critical requirements. It is intended that the test be applicable to the selection of personnel for positions in research and engineering laboratories. It should be particularly applicable for administration at the college senior level to select candidates for advanced training in physical science and engineering.

The specific behaviors given in the list serve as the basic data which determine the numbers and kinds of items to be developed. Items will be prepared by studying the critical behaviors and constructing items in which each of these behaviors forms the basis for one or more test problems.

The rationale for each of the various types of items will be as tightly logical as possible. For example, the reasoning would not be of

the type: "A number of men failed because of inability to understand written materials. Understanding of written materials is measured by the verbal factor. A test of the verbal factor is the Cooperative Vocabulary Test. The Cooperative Vocabulary Test should provide a valid measure of this critical requirement of an effective research worker." Instead, much more detailed definitions will be required of the type of materials not understood. The inferences made will be much more restricted. The final items developed will have to appear to representative scientists serving as critics as clearly relevant to the requirements being predicted.

#### Guiding Principles in Item Construction

It is intended that the test shall measure aptitude rather than academic achievement or knowledge gained through technical experience. For this reason it is essential that all specific information necessary to the solution of test items be given so that the subject's success or failure on specific items will depend upon his ability to manipulate information in a desired manner, and not on his possession of that information. However, a minimum knowledge of general principles in the basic physical sciences will probably be operative. It is therefore assumed that all individuals will have a minimum common background of a year's college course in physics, in chemistry, and in mathematics. However, each individual's background in these areas will vary with the field of specialization, and since it is desired that individuals in all the physical and engineering sciences shall take the test without the results being unduly influenced by course background, a balance of subject-matter content will be necessary. Most of the subject-matter will be taken from physics, chemistry, and mathematics, but a limited number of items concerned with engineering and biological science

may be included if presented so that no special advantage or disadvantage will be given to particular groups.

It is also desirable that situations described in particular items should seem appropriate in both a university and a research laboratory situation. Since some individuals will take the test without the benefit of on-the-job experience, they should not be called upon to handle items where such experience would be crucial to the solution.

Since the test may ultimately be administered by the Civil Service Commission, the items must be of the objective type. It is believed that the five-choice item will be most useful, but the test will not necessarily be limited to that type. On the whole, items will require rather detailed presentation of information essential to their solution. Since many of the critical requirements are related, it would be desirable to relate a number of questions to a single detailed paragraph description. This would have a double advantage in making the maximum use of the materials in the paragraph and in permitting the measurement of the integration of knowledge about a series of related problems.

#### Suggestions for Preparation of Items

1. It is desired that items closely related to specific critical behaviors be developed.
2. Test items should be objective (preferably five-choice) and all specific information necessary for solution should be given.
3. Whenever possible, items should be constructed for a group of logically related behaviors by preparing detailed reference or descriptive material and presenting a series of questions concerning it.

4. The situations and problems used in writing items should preferably be original. Subject-matter sources may be consulted when necessary, but any materials taken from them are to be altered so that no special advantage will be had by those who know the source.
5. We would prefer to have items typed on 5 x 8 cards with the correct alternate keyed on the back. Alternate choices should be numbered (1, 2, 3, 4, etc.) Each item should be coded to the area (Roman numeral) sub-area (capital letter) I or E for effective or ineffective and item (small numeral) for which it was written. A brief statement of what the test item is believed to measure should be given on the back of the card. Please sign or initial all items prepared.

PROJECT FOR THE DEVELOPMENT OF SELECTION INSTRUMENTS  
TO MEASURE APTITUDES FOR SCIENTIFIC WORK

MEMORANDUM FOR TEST CRITICS

The Office of Naval Research is currently sponsoring a project concerned with the development of an aptitude test for the selection of research personnel. The project is being carried out by the American Institute for Research, a non-profit personnel research organization, and is a continuation study undertaken after completion of an earlier project which resulted in the identification of the critical requirements for research personnel.

The objective of the project is the development of test items to be used in the selection of candidates for advanced training in natural science and engineering. The numbers and kinds of problems sampled by the test items are based on the list of critical behaviors found in the preceding study. It is not intended to measure knowledge or experience, but rather to determine how well the individual can solve a new problem when all of the necessary technical information is given. The items contain problems in a variety of subject-matter areas, but are intended to be equally difficult for persons trained in a variety of technical specialties. It is assumed that all who take the test will have had at least one year's college training in physics, chemistry, and mathematics. All pertinent technical information beyond this level is given in the statement of each problem, so that persons unfamiliar with the particular field will not be at a disadvantage.

A number of items have been developed, each containing a statement of the problem to be solved, and five possible answers from which the correct one is to be selected. The items are still in a preliminary form, but it is essential that they be reviewed by scientifically trained critics at this stage. Criticism will be particularly helpful if it is directed at the following two points:

1. Would you expect successful solution of the item to be predictive of success in the area of behavior the item was intended to measure?
2. Do you consider the intended answer the only correct choice, or clearly the best choice of those offered?

Samples of two items and criticisms that have been applied to them are given below. Each item is given in the left-hand column, beginning with a brief paragraph stating the problem to be solved, and followed by the five possible choices. The answer intended as correct is indicated by an "X". Below each item are statements which indicate the type of behavior which the item was designed to predict.

Criticisms are given in the right-hand column, opposite the item to which they apply. Each critical comment is numbered 1 or 2 to correspond with the two types of criticism requested.

#### ITEM 1

#### CRITICAL COMMENTS

Any field of energy is distorted by whatever device is employed for observing it. This implies that

- |   |   |
|---|---|
| <ol style="list-style-type: none"> <li>1. it is pointless to speak of fields of energy.</li> <li>X 2. quantitative statements about given fields of energy must take into account the characteristics of the observing instrument.</li> </ol> | <ol style="list-style-type: none"> <li>1. The item does not apply directly to "making provision for equated conditions"; it is more concerned with ability to determine the logical implications of a statement.</li> </ol> |
|---|---|

3. exact quantitative laws cannot be determined for fields of energy.
4. some other means of observing fields of energy should be sought.
5. whatever is meant by "field of energy" should be made more specific.
2. Choice 3 could be considered right as well as 2, since it is an implication of the statement, though not as obvious an implication.

Intended to predict:

Planning and Designing the Investigation (Major Area)

Identifying and Controlling Important Variables (Sub-area)

Made provision for equated conditions in planning comparison tests  
(Critical Behavior)

ITEM 2

CRITICAL COMMENTS

You are performing a test involving colorimetry. You have never performed the test before, but you have a manual of standard procedures. Your task is to match the color of an unknown substance with a standard. This is done by adding a solution to the unknown until you have the desired match and recording the amount of solution that was required. You perform the test twice and obtain two different readings. What should you do in order to decide on a proper reading?

1. Yes, the item should predict what is indicated.
2. #5 is the only correct choice if it means "do something other than 1, 2, 3, or 4"; however, it is not clear--it could mean "use some procedure other than colorimetry procedures."

1. Use your first reading, since the unknown substance might be unstable.
2. Use your second reading, since practice has probably improved your skill.
3. Take an average of the two readings.
4. Have another person run the test and use that one of the two values that is nearest to the one obtained by him.
- X 5. Some procedure other than those mentioned above.

Intended to predict:

Planning and Designing the Investigation (Major Area)

Determining the Number of Observations (Sub-area)

Reported investigation complete only after data had been taken in sufficient quantity to permit conclusive interpretation (Critical Behavior)

American Institute for Research

13 December 1949

PROJECT FOR THE DEVELOPMENT OF SELECTION INSTRUMENTS  
TO MEASURE APTITUDES FOR SCIENTIFIC WORK

MEMORANDUM FOR EDITORIAL REVIEWER

The purpose of this review of the items is twofold: (1) to edit them for technical (subject-matter) content, and (2) to edit for maximum conformance to the principles of good item-construction. If time limitations force a choice, priority should be given to the first.

Materials Enclosed:

- (1) A memorandum describing background and rationale of the test development project
- (2) A copy of each of two forms of the test (labeled MTM and BT) with the keyed choices circled; these copies also contain the responses of examinees to each choice for all items where tryout data are available. A description of tryout groups is also given.
- (3) A second (blank) copy of each of the two forms intended for editorial notes

Editorial Comment Requested:

- (1) Specific changes recommended, to be written into the items themselves
- (2) Brief explanation of reasons for changes and any comments, questions, or reservations about specific items

PROJECT FOR THE DEVELOPMENT OF SELECTION INSTRUMENTS  
TO MEASURE APTITUDES FOR SCIENTIFIC WORK

MEMORANDUM FOR RATIONALE REVIEWERS

Enclosures:

- (1) A memorandum describing the background and rationale of the test; (we suggest you scan this for general information).
- (2) A set of "rationales" for 150 items; each of these contains a critical behavior listed under the appropriate major area and subarea. Then follows a statement of our hypothesis as to the processes, abilities, or traits which are believed necessary for the performance of that behavior. Stapled to each of these statements is a keyed test item (or items) prepared for the critical behavior and growing out of the indicated rationale. The last paragraph of each rationale relates the specific item (or items) to the critical behavior and rationale. The first rationale in the group has all of these elements labeled for your information. (This is the material we would like to have you criticize.)
- (3) The Observational Record Form for Scientific Personnel, which contains all of the critical behaviors organized under the major areas and subareas; (this is sent along for reference).
- (4) A set of sample critical incidents, giving two or three incidents for each subarea; these incidents are illustrative of the data from which the critical behaviors were formulated. (These are included in case you wish to see the general form of the critical incidents.)

Specific Directions:

The major purpose of this review of the test is to obtain critical judgments of how well the types of items developed fulfill the intended purposes. On each page, one of the critical behaviors is presented. The rationale which follows states our hypothesis as to how behavior of this specific type can best be predicted; the items represent the attempt to do so.

Criticize the hypothesis (rationale) and the item. Will performance on this type of item predict the critical behavior in the job situation?

We are interested in identifying those types of items which will, and those which will not, predict the critical behaviors. For those which you believe will not, we would like to know what changes will make them suitable. Since the project is nearing completion, we are more interested in the improvement of these rationales, and to a lesser extent these items, than in entirely new ideas. However, your ideas for new rationales or items will certainly be welcomed.

Please record your comments in the space below each rationale, and suggested item changes on the attached copy of the item. Also please consider each set in order since the orders are staggered for the different reviewers to achieve maximum coverage.

As an incidental part of the review, you may wish to suggest editorial changes based on the technical requirements of a good item. This, however, is not the major purpose of the review.

## Appendix II

### CRITICAL REQUIREMENTS FOR RESEARCH PERSONNEL

Appendix II contains the list of critical requirements for research personnel developed in a preceding study. The list is based on job behaviors reported by scientific personnel as crucial to successful performance in natural science and engineering. These job behaviors represent the basic data to which the test development project was referred. Each test item was designed to predict a specific critical behavior.

The behaviors were grouped under eight major areas and thirty-six subareas. They are here presented in outline form; the major area (Roman numeral) is given first, and then the subarea (capital letter). The appropriate lists of effective and ineffective behaviors follow each subarea heading.

## CRITICAL REQUIREMENTS FOR RESEARCH PERSONNEL

### I. Formulating Problems and Hypotheses

#### A. Identifying and Exploring Problems

##### Effective Behaviors

1. Investigated chance findings or comments suggesting a new problem.
2. Investigated unexpected results or difficulties encountered in work.
3. Chose for investigation a problem for which solution was urgently needed.
4. Suggested a new problem which could be studied with an already successful technique.
5. Proposed an entirely new problem or line of research.
6. Suggested that a previously unsolved problem could be studied with methods or materials recently made available.
7. Conducted preliminary investigation to see whether phenomena merited experimental as well as theoretical study.
8. Conducted preliminary investigation to furnish basic data essential to work on a practical problem.
9. Applied material from a current course of study to problem.

##### Ineffective Behaviors

1. Failed to investigate chance findings or comments suggesting a new problem.
2. Failed to investigate unexpected results or difficulties encountered in work.
3. Worked on a problem which had already been solved or proved unproductive.
4. Allowed a successful technique to be dropped without further application to new problem.
5. Overlooked a problem in current work meriting further research.

#### B. Defining the Problem

##### Effective Behaviors

1. Proposed investigation of basic factors and implications involved in the problem as well as its superficial aspects.
2. Defined the problem and objectives of investigation.
3. Gathered information on exact requirements, specifications, and goal of assigned project.
4. Proposed investigating only factors which could be studied in time available.
5. Outlined investigation of only those factors whose control was feasible.
6. Submitted a plan covering both theoretical and experimental aspects of problem.

##### Ineffective Behaviors

1. Proposed an investigation confined to superficial aspects of problem.
2. Began work without defining problem or objectives of investigation.
3. Failed to obtain information needed to define the requirements, specifications, and goal of assigned project.
4. Chose a problem which did not lend itself to investigation because of practical limitations.

### C. Setting Up Hypotheses

#### Effective Behaviors

1. Proposed hypothesis or general formula in order to explain observed phenomena.
2. Predicted phenomena by theoretical or mathematical analysis.
3. Extended a theory to cover a broader range of problems.
4. Reformulated a theory to improve its explanation of the facts.
5. Applied theory from another field to explain observed phenomena.
6. Provided explanation of phenomena derived from analogous situation in the same field.

#### Ineffective Behaviors

1. Proposed program of data collection undirected by any hypothesis.
2. Proposed hypothesis contrary to known facts.

## II. Planning and Designing the Investigation

### A. Collecting Background Information

#### Effective Behaviors

1. Sought out information and ideas from existing literature, associates, or experts on problem before beginning work on project.
2. Included all relevant sources in surveying the literature or consulting experts.
3. Questioned the validity of material in the literature.
4. Obtained needed information from an uncommon source.
5. Made himself best-informed person in his group on special subject.
6. Suggested that literature he had read in the past might apply to a current problem.
7. Performed experiments or gathered necessary information directly which was unavailable in usual sources.

#### Ineffective Behaviors

1. Did not consult those intimately concerned with problem, or investigate existing literature before beginning work on project.
2. Omitted an important source in surveying literature or consulting experts.
3. Took action based on information from an unreliable source.

### B. Setting Up Assumptions

#### Effective Behaviors

1. Based plan on assumptions which closely approximated actual conditions.
2. Secured evidence of validity of assumptions.
3. Verified previous work before basing assumptions on it.

#### Ineffective Behaviors

1. Outlined plan which was dependent on false assumptions or assumptions inapplicable to specific problem.
2. Failed to secure evidence of validity of assumptions.
3. Based outline of investigation on opinion or previous work of others without question.

### **C. Identifying and Controlling Important Variables**

#### **Effective Behaviors**

1. Outlined plan permitting control and systematic variation of all relevant variables.
2. Made provision for equated conditions in planning comparison tests.
3. Simulated actual conditions in a laboratory test.
4. Described or outlined plans in which the various factors were treated in accordance with their relative importance.
5. Pointed out the significance of a factor overlooked or dismissed as trivial by others.

#### **Ineffective Behaviors**

1. Outlined plan for experiment without control and systematic variation of all relevant variables.
2. Failed to make provision for equated conditions in planning comparison tests.
3. Failed to simulate actual conditions in a laboratory test.
4. Described or outlined plans in which the various factors were not treated in accordance with their relative importance.

### **D. Developing Systematic and Inclusive Plans**

#### **Effective Behaviors**

1. Included all relevant factors or phases in outlining plans for the investigation.
2. Presented plans which included methods of integrating one factor or phase with others.
3. Pointed out the basic factors in a mass of information about the problem.
4. Tried out various approaches to problem before choosing one.
5. Outlined plan calling for each element of problem to be studied in sequence.

#### **Ineffective Behaviors**

1. Omitted a relevant factor or phase in outlining plans for an investigation.
2. Presented plans in which one factor or phase was considered in isolation from related phases.
3. Listed an irrelevant factor in plan of investigation.

### **E. Developing Plans for the Use of Equipment, Materials, or Techniques**

#### **Effective Behaviors**

1. Included in plan of investigation equipment, material or techniques which met the requirements of the problem.
2. Chose a simplified technique which produced results of required standard.
3. Planned to use substitute equipment or material which met standards and saved time or money.
4. Planned to modify available equipment, materials, or techniques for use on a new problem.
5. Planned to use technique or equipment which would eliminate doubt of validity or accuracy of results.
6. Chose the latest development of an appropriate equipment, technique, or material.
7. Conducted pilot study to determine feasibility of proposed techniques, materials, or equipment.
8. Set up work for procedure in most efficient physical arrangement for handling details easily.

### Ineffective Behaviors

1. Included in plan of investigation equipment, material, or techniques not fitted to the requirements of the problem.
2. Planned to use equipment or materials more complex or expensive than necessary to produce results of required standards.
3. Suggested trial and error method for a problem that required a controlled, systematic approach.
4. Overlooked available materials, equipment, or techniques suitable to investigation in drawing up plans.
5. Proposed use of equipment, material, or technique successful in a related field without specifying modifications necessary to fit specific problem.
6. Presented plan to use a procedure that had never been tested.
7. Failed to suggest ideas on approach to problem or sources for ideas.

### F. Anticipating Difficulties

#### Effective Behaviors

1. Made provision for meeting difficulties likely to arise at later stages.
2. Included in plans internal or independent check on accuracy of data or method.
3. Outlined probable consequences of various alternative approaches.
4. Outlined alternate approach to be used if first choice failed.
5. Took special precautions in planning to prevent damage to equipment.
6. Organized work so that changes could be made easily when they became necessary.

#### Ineffective Behaviors

1. Made no provision for handling difficulties which might arise at later stages.
2. Failed to set up internal or independent check on accuracy of data or methods.

### G. Determining the Number of Observations

#### Effective Behaviors

1. Outlined plan of investigation which provided for sufficient quantity of data to be taken.

#### Ineffective Behaviors

1. Outlined plan of investigation which did not provide for sufficient quantity of data to be taken.
2. Outlined plan of investigation calling for the collection of considerably more data than necessary.

## III. Conducting the Investigation

### A. Developing Methods, materials, or Equipment

#### Effective Behaviors

1. Devised an improved method, material, or equipment.
2. Incorporated ideas from another field in developing a method, material, or equipment.
3. Developed an entirely new method, material, or equipment to fill a need.
4. Adapted available equipment to meet requirements of new problem.
5. Wrote specifications for proposed equipment from knowledge of its purpose.
6. Showed experimentally the capabilities of method, material, or equipment he developed.

### Ineffective Behaviors

1. Developed a new method when appropriate one existed.
2. Produced a new method, material, or equipment which was less effective than existing one.
3. Failed to make adaptation of existing method, material, or equipment to permit its use in a specific problem.
4. Developed method, material, or equipment which did not meet assigned specifications or recognized need.
5. Designed equipment too impractical to be produced or used.

### **B. Applying Methods and Techniques**

#### Effective Behaviors

1. Used a technique, material, or equipment which solved problem or eliminated difficulty in the investigation.
2. Pointed out that method or device did not meet the requirements of the investigation.
3. Substituted a method, technique, or equipment giving results better than the one in current use.
4. Used substitute material or simplified procedure that met standards and saved money and time.
5. Applied critical tests of equipment or material correctly.
6. Tried even unlikely methods after obvious methods had failed.
7. Demonstrated that material, technique, or equipment could be used for purposes other than original ones.
8. Taught himself to operate equipment without supervision.

#### Ineffective Behaviors

1. Used equipment, material, or technique incorrectly.
2. Used a technique more complex or expensive than necessary to obtain desired result.
3. Attempted to use a method which violated fundamental laws.
4. Followed standard procedure or suggestion to the letter without modifying it to fit specific situation.
5. Estimated data when accurate methods of measurement were available.
6. Failed to apply a method provided for in plans.
7. Failed or erred in performance of a simple operation after instruction or study.
8. Failed to find the cause of difficulty in operation of equipment.
9. Followed inapplicable or unorthodox methods in construction or maintenance of equipment.

### **C. Modifying Planned Procedures**

#### Effective Behaviors

1. Modified standards, methods, or work schedule to meet deadline without reducing essential value of results.
2. Modified work to incorporate latest research findings.
3. Adopted alternate procedures as soon as unforeseen negative conditions or difficulties were encountered.
4. Held up phases of work until results of earlier phase were available.
5. Accepted partial results or temporary solution to an urgent problem.
6. Anticipated the probable effect of a defect or difficulty and took appropriate action.
7. Took emergency action which prevented damage or injury.

### Ineffective Behaviors

1. Failed to modify standards, methods, or work schedule to meet deadline.
2. Omitted an essential step or precaution for accuracy in order to meet deadline.
3. Continued to follow old method or approach without change when evidence showed it had failed.
4. Began work on a phase of project without waiting for results of earlier phase.
5. Refused to accept partial results or temporary solution to an urgent problem.
6. Ordered a change causing damage, incorrect performance, or inaccuracy.
7. Abandoned or modified a method or device before sufficient evidence had been gathered.
8. Modified only a part of the materials or procedures giving trouble.
9. Started and abandoned several methods without following any far enough to justify rejection.

### D. Applying Theory

#### Effective Behaviors

1. Performed an unfamiliar calculation or operation without instruction.
2. Made an application of new or complex material to own work after brief explanation.
3. Presented unique solution or technique developed by mathematical analysis.
4. Transformed physical problem so that it could be solved by mathematical analysis.
5. Explained phenomenon by analyzing procedures used or data obtained.
6. Determined the purpose or operation of a device by studying its construction.
7. Explained technical subjects or answered questions of others.

### Ineffective Behaviors

1. Failed to solve a problem requiring only direct application or elementary extension of textbook principles.
2. Failed to answer a technical question or gave incorrect information.
3. Presented an erroneous mathematical solution.
4. Requested repeated or more simplified explanation of a theoretical point.
5. Omitted or misinterpreted implications of fundamental theory in explaining application to a problem.

### E. Attending to and Checking Details

#### Effective Behaviors

1. Followed all essential details of prescribed procedures for a routine operation.
2. Performed work which met standards for accuracy on project.
3. Handed in work only after he had checked it.
4. Held up work until equipment was checked.
5. Kept systematic, detailed record of project, permitting repetition or evaluation of procedures.
6. Recorded essentials of conference or decision for supervisors' information.
7. Called attention to a significant detail or error occurring in regular performance of duty.
8. Checked results at end of each phase before proceeding.

#### Ineffective Behaviors

1. Omitted an essential detail of prescribed procedures for a routine operation.
2. Turned in work which had to be re-done because it contained errors.
3. Failed to check work before handing it in.
4. Used equipment without first calibrating or checking it.
5. Failed to keep record of project, making repetition or evaluation of procedures impossible.
6. Failed to record essentials of conference or decision for supervisors' information.
7. Failed to call attention to a significant detail or error occurring in regular performance of duty.
8. Did not investigate a simple or obvious clue to cause of phenomenon.
9. Gave disproportionate time and attention to small details of procedure.
10. Failed to check on details of procedure before beginning work.
11. Took action based on the word of others without checking validity or applicability.

#### **F. Analyzing the Data**

##### Effective Behaviors

1. Used the most efficient method for analyzing data.

##### Ineffective Behaviors

1. Applied a formula to his data which could not give required information.
2. Calculated statistics unnecessary for data obtained.
3. Failed to make the necessary mathematical analysis of his data.

#### **IV. Interpreting Research Results**

##### **A. Evaluating Findings**

##### Effective Behaviors

1. Produced conclusions or recommendations supported by data.
2. Drew conclusions in accordance with correct logical principles.
3. Presented results of a check on validity of conclusions.
4. Indicated correct interpretation of research results.
5. Pointed out whether or not the evidence was conclusive.
6. Pointed out the limitations of data or method, including conflicting elements.

##### Ineffective Behaviors

1. Drew conclusions not supported by the data.
2. Presented a conclusion violating logical principles.
3. Did not present a check on validity of conclusions.
4. Failed to draw conclusions from data or to show solution to problem.
5. Drew conclusions from incomplete, inadequate, or erroneous data.

##### **B. Pointing Out Implications of Data**

##### Effective Behaviors

1. Pointed out new and useful implications of work.
2. Worked out applications to other problems or fields.

### Ineffective Behaviors

1. Failed to report implications and possible extensions of work.
2. Pointed out implications which should have been further extended.
3. Pointed out implications which were inapplicable.

## V. Preparing Reports

### A. Describing and Illustrating Work

#### Effective Behaviors

1. Pointed out important details of procedure or results.
2. Included sufficient detail to guide work on similar problems.
3. Kept statement of problem and conclusions brief enough for quick grasp.
4. Explained new material when first introduced.
5. Gave examples of practical applications or a simplified statement of complex theory.
6. Used graphic, tabular, or pictorial material to clarify text.
7. Defined all terms and symbols.
8. Used a simple system of designation for items.
9. Used simple, direct language and concrete words.

#### Ineffective Behaviors

1. Failed to state purpose of report or project.
2. Gave excessive detail in descriptive materials.
3. Failed to emphasize major findings or overemphasized unimportant findings.
4. Discussed at length elementary theory or well-known materials.
5. Omitted necessary illustrative material.
6. Used inaccurate labels on illustrative material.
7. Gave inaccurate references.
8. Used incorrect or unorthodox symbol.
9. Presented ambiguous definition of terms or symbols.
10. Made excessive use of complex sentence structure or unusual words.
11. Violated correct English usage.

### B. Substantiating Procedures and Findings

#### Effective Behaviors

1. Described fully the basic principles involved.
2. Described all significant elements of experiment, conditions, and results.
3. Gave enough data to permit reinterpretation or checking of work.
4. Included detailed reasoning leading to conclusions presented.
5. Explained the effect of method used on conclusiveness of results.
6. Gave explicit statement of underlying assumptions and inferences.
7. Presented logical explanation of unexpected results.
8. Gave an especially complete, relevant bibliography.

#### Ineffective Behaviors

1. Failed to give sufficient background or theory for full understanding.
2. Failed to state underlying assumptions.
3. Omitted major elements of work.
4. Omitted details necessary for application or checking of work.
5. Failed to give full reference to related work.
6. Omitted necessary bibliography.
7. Gave abstruse theory without presenting proof.
8. Failed to give derivations of equations or formulas.
9. Failed to present material on which conclusions were based.

### C. Organizing the Report

#### Effective Behaviors

1. Followed a logical outline.
2. Gave problem and introductory material at the beginning of the report.
3. Summarized the important points.
4. Tabulated data in chronological or logical order.
5. Presented conclusions in order of importance.
6. Separated background material or discussion from presentation of method.
7. Placed lengthy or detailed analysis or data in appendix.
8. Placed references in appropriate location.

#### Ineffective Behaviors

1. Failed to give plan and scope of the problem at the beginning of the report.
2. Failed to bring out the main points.
3. Separated related sections or materials.
4. Jumped from one point to another.
5. Failed to give cross-index from outline to details.
6. Presented figures or tables in order not corresponding to text.
7. Gave technical details in body of report.

### D. Using Appropriate Style in Presenting Report

#### Effective Behaviors

1. Used a style adapted to audience or readers.
2. Enunciated carefully.
3. Presented work without undue apology or ostentation.
4. Heightened interest and stimulated thought by skillful manner of presentation.

#### Ineffective Behaviors

1. Used "lab jargon" or unduly informal style.
2. Represented sales rather than scientific viewpoint.
3. Had no "audience appeal."
4. Spoke hesitantly or with faulty delivery.

## VI. Administering Research Projects

### A. Selecting and Training Personnel

#### Effective Behaviors

1. Recruited personnel necessary to meet commitments.
2. Assigned worker a project suiting ability or training.
3. Gave constructive suggestions to subordinates.
4. Checked subordinate's progress at critical points.
5. Started instructional procedures for subordinate.
6. Explained necessary details of project to subordinates.
7. Made suggestions to subordinates only after learning details.

#### Ineffective Behaviors

1. Assigned personnel without reference to their training or familiarity with work.
2. Offered subordinate no suggestions.
3. Failed to discuss problems with subordinate when necessary.
4. Failed to check subordinate's work.
5. Gave instructions too general to cover essentials.

**B. Dealing With Subordinates**

**a. Administering Reprimands, Recognition, and Praise**

**Effective Behaviors**

1. Secured promotion, recognition, or praise for deserving subordinate.
2. Reprimanded worker without disparagement.
3. Refused to reprimand worker without the facts.
4. Pointed out importance of their work to subordinates.

**Ineffective Behaviors**

1. Reprimanded a worker without reference to facts.
2. Failed to administer a warranted reprimand.
3. Reprimanded a worker in front of associates.
4. Upheld a worker without knowing facts.
5. Failed to retract an unwarranted reprimand.
6. Disparaged the ideas or efforts of a subordinate.
7. Did not introduce subordinate to a visitor interested in his work.

**b. Looking Out for Subordinates' Welfare**

**Effective Behaviors**

1. Arranged a schedule acceptable to subordinates.

**Ineffective Behaviors**

1. Demanded unnecessary hours or production.
2. Unnecessarily refused a worker leave.

**c. Keeping Subordinates Informed**

**Effective Behaviors**

1. Explained reasons for adverse or controversial administrative action.

**Ineffective Behaviors**

1. Did not explain administrative action affecting subordinates' work.
2. Did not inform subordinates of plans or decisions.

**d. Sharing Responsibility**

**Effective Behaviors**

1. Discussed problem areas with subordinates.
2. Asked for or accepted subordinates' ideas.
3. Participated in important phases of a subordinate's work.
4. Delegated responsibility for details.
5. Made only essential checks on subordinates' work.
6. Supported considered decision of subordinate.

**Ineffective Behaviors**

1. Gave subordinates no opportunity to present ideas at planning conference.
2. Failed to investigate or consider subordinates' suggestions.
3. Failed to participate in subordinates' work.
4. Did not delegate work or responsibility.
5. Verified every detail of subordinates' work.
6. Gave his own work to subordinates.
7. Did work with which he was less familiar than subordinates.

C. Planning and Coordinating the Work of Groups

a. Selecting Projects

Ineffective Behaviors

1. Approved or selected projects which could not be handled.
2. Refused projects which could be handled.

b. Estimating and Supplying Project Needs

Effective Behaviors

1. Outlined and scheduled personnel needs.
2. Scheduled facilities and equipment for use by several groups.
3. Had supplies available when needed.
4. Developed a system facilitating procurement of supplies.
5. Went outside of usual supply channels when necessary.
6. Ordered supplies from most economical source.

Ineffective Behaviors

1. Submitted plans with vague steps and time estimates.
2. Made erroneous estimate of personnel needs.
3. Failed to request facilities via proper channels.
4. Failed to reorder stock in time for use.

c. Organizing the Work of Projects

Effective Behaviors

1. Assigned homogeneous units of work to groups.
2. Suggested changes in method which facilitated work.
3. Simplified or standardized routine procedure.

Ineffective Behaviors

1. Assigned no problems to group.
2. Delayed making assignments.
3. Gave high priority to a minor task.
4. Assigned personnel to one project at expense of another.
5. Failed to designate supervisor for project.

d. Unifying Related Groups

Effective Behaviors

1. Proposed consolidation of related projects into unified program.
2. Eliminated or reduced overlapping and duplication between groups.

Ineffective Behaviors

1. Failed to coordinate related projects.

D. Making Administrative Decisions

a. Making Needed Decisions

Effective Behaviors

1. Made decision and issued instructions promptly in emergency.

Ineffective Behaviors

1. Delayed making a needed decision.
2. Failed to make a decision which was his responsibility.
3. Revised a decision without improving it.

b. Following Regulations in Decisions

Effective Behaviors

1. Deviated from standard administrative procedure to handle emergency.

Ineffective Behaviors

1. Took administrative action inconsistent with agency policy.
2. Deviated from standard procedure in non-emergency situation.
3. Went outside of regular channels to solicit favorable decision.
4. Refused to make an exception to regulation when situation demanded it.

c. Basing Decisions on Facts

Effective Behaviors

1. Decided only after gathering all pertinent facts.
2. Gave out information only after checking facts.

Ineffective Behaviors

1. Announced decision before studying evidence.
2. Gave out information before checking facts.
3. Based decision on ideas of personnel unfamiliar with problem.

E. Working With Other Groups

Effective Behaviors

1. Obtained cooperation or action essential to project.
2. Got opposing groups to agree.
3. Pointed out mutual problems of groups.
4. Expedited joint project independently without offending cooperating group.
5. Checked closely on work being done by another group.

Ineffective Behaviors

1. Failed to get action from cooperating group.
2. Antagonized members of cooperating group.
3. Failed to request action from another administrative level on vital issue.
4. Failed to inform cooperating groups of decisions or actions affecting their work.
5. Neglected to make personal contacts essential to progress of project.
6. Refused to lend related groups equipment or supplies.

VII. Accepting Organizational Responsibility

A. Performing Own Work

a. Doing Work Promptly

Effective Behaviors

1. Completed difficult or extensive assignment on schedule without omitting essential checks on quality of work.
2. Started work as soon after receiving assignment as priority permitted.
3. Began to work directly on the problem after only a necessary amount of preliminary study and exploration.

#### Ineffective Behaviors

1. Did not complete assigned job in time allotted.
2. Put work aside after receiving assignment though he had no other pressing work.
3. Failed to prepare for an important step until the last minute, resulting in inadequate preparations.
4. Failed to write report of project until prodded.

#### **b. Accepting Responsibility for Own Work**

##### Effective Behaviors

1. Completed a difficult assignment without supervision or help.

##### Ineffective Behaviors

1. Asked others to solve a problem or indicated unwillingness to undertake a problem which was his responsibility.
2. Asked others to help on an unformulated problem.
3. Stated that an assigned job couldn't be successfully done, and spent a good deal of time expounding on its difficulties.
4. Left incomplete work in such condition that others could not complete it.

#### **c. Allocating Own Time and Effort**

##### Effective Behaviors

1. Proceeded to next step of project without waiting to be told.
2. Outlined a plan for solving a new problem on his own initiative.
3. Took on an additional duty voluntarily.
4. Organized work to permit carrying out several different tasks concurrently.

##### Ineffective Behaviors

1. Did not go beyond carrying out specific instructions even though next step needed doing.
2. Stopped work when preliminary results were obtained, failing to completely finish the job.
3. Spent time doing more work on an assignment than desirable considering the nature of the assignment.
4. Got side-tracked on irrelevant details.
5. Dissipated efforts over several problems in different fields.

#### **B. Assisting in the Work of Others**

##### Effective Behaviors

1. Passed on a successful technique or finding to others.
2. Offered information, assistance, or suggestions to other workers.
3. Kept interested persons and groups fully informed on progress of project.
4. Reported progress with written reports requiring minimum of superior's time.
5. Consulted supervisor about usefulness of an original idea.
6. Pointed out inadequacies of a plan, regulation, or policy to group responsible for it.

##### Ineffective Behaviors

1. Neglected to pass on an important finding to others.
2. Failed to provide information or assistance requested by workers on related projects.
3. Criticized work of others without making suggestions for improvement.

### C. Subordinating Personal Interests

#### Effective Behaviors

1. Pursued main problem without being side-tracked by personal interests in other work.
2. Dropped major interest to study less interesting project more closely related to goal.
3. Accepted necessary reduction in scope, personnel, or facilities of his program.
4. Maintained own morale and efficiency or that of subordinates in the face of difficulties.

#### Ineffective Behaviors

1. Worked on problems interesting to him but not directly related to assigned work.
2. Digressed or discussed irrelevant details in a conference.
3. Objected to necessary reduction in scope, personnel, or facilities of his program.
4. Refused to work on a project unless given desired type of work, or a salary increase.
5. Requested that work of others be rearranged to conform with own plans or ideas.
6. Gave orders to personnel over whom he had no authority.

### D. Accepting Regulations and Supervision

#### Effective Behaviors

1. Requested clarification of assignment when in doubt.
2. Solicited aid from superior when faced with difficulties.
3. Reported progress and probable delays to superior.

#### Ineffective Behaviors

1. Failed to ask for clarification of instructions until he made a mistake.
2. Failed to request aid when needed.
3. Failed to report progress or delay to superior.
4. Instituted changes in procedures without consulting superior.
5. Accepted an impossible assignment without question.
6. Failed to comply with a regulation, order, or instruction.
7. Insisted that regulations be waived in his case.

## VIII. Accepting Personal Responsibility

### A. Adapting to Associates

#### Effective Behaviors

1. Criticized the work of another without disparaging his efforts.
2. Gave specific answers to questions of others.

#### Ineffective Behaviors

1. Made disparaging remarks about others or their work.
2. Gave vague answers to questions of others.
3. Criticized work of others without studying it carefully.
4. Quarrelled with or spoke rudely to other staff members.
5. Interrupted work of others to discuss personal or irrelevant matters.

## **B. Adapting to Job Demands**

### **Effective Behaviors**

1. Accepted the suggestions and advice of a supervisor or other expert gladly.
2. Continued to work according to plan in spite of obstacles or opposition.
3. Completed work even though assigned to job distasteful to him.
4. Worked overtime to meet a deadline.
5. Performed work normally delegated to others in order to avoid delay.

### **Ineffective Behaviors**

1. Refused to accept criticism or advice.
2. Slowed up or abandoned project when faced with obstacles or opposition.
3. Failed to turn out work when assigned to job distasteful to him.
4. Refused to work overtime to meet a deadline.
5. Requested leave during peak work period.
6. Decreased efforts after unwanted change in job-status or work-situation.
7. Was absent from work without legitimate reason.
8. Refused to give up a project in spite of evidence proving it to be useless.

## **C. Meeting Personal Commitments**

### **Ineffective Behaviors**

1. Failed to perform a specifically assigned task to which he had agreed.
2. Performed an assignment in a way different from that agreed upon.
3. Failed to report for an important appointment or conference.

## **D. Being Fair and Ethical**

### **Effective Behaviors**

1. Presented favorable and unfavorable evidence in reporting results or making recommendations.
2. Gave credit for ideas or work to those responsible.
3. Reported his conclusions despite possible jeopardy to position.

### **Ineffective Behaviors**

1. Deleted or glossed over evidence which would have revealed errors, omissions, or unfavorable conclusions.
2. Failed to give credit for ideas or work of others.
3. Substituted his work for that of others without their consent.
4. Falsified data.
5. Blamed others or made excuses for his own errors or failures.
6. Argued that wrong action was acceptable.
7. Made untrue statements about work or its progress.
8. Made false charges against another.

## **E. Showing Interest in Work**

### **Effective Behaviors**

1. Worked on own time to improve technical knowledge and proficiency.
2. Suggested that he take a special training course applicable to his assignment.
3. Discussed ideas and plans for project enthusiastically.
4. Asked subordinates to educate him by explaining their work in detail.

### **Ineffective Behaviors**

1. Turned down an offer to study on government time.
2. Devoted time on the job to social visiting or to personal work.
3. Showed little enthusiasm in discussing plans for project.

### Appendix III

#### RATIONALES RELATING TYPES OF TEST ITEMS TO THE CRITICAL BEHAVIORS

Appendix III contains "rationales" relating types of test items to the specific critical behaviors they were designed to predict. The rationales are presented here to illustrate the general types of items developed. It is also believed that the rationales may be of interest to others concerned with the development of measures of scientific aptitude.

The rationales are presented in an outline form corresponding to that used in the list of critical requirements. Each rationale contains: (1) a statement of the major area (Roman numeral), subarea (capital letter), and critical behavior (arabic numeral) concerned; (2) a statement of hypotheses as to the knowledges, abilities, or personality traits believed to underlie that critical behavior, under the heading, "This behavior seems to involve"; (3) a description of the type of test item it is believed would appropriately sample these knowledges, abilities, or traits, under the heading, "An item intended to predict this behavior." More than one type of test item is suggested for some critical behaviors. In a few cases types of test items are suggested for a group of critical behaviors (subarea) and the rationale then presents an analysis of the subarea.

RATIONALES RELATING TYPES OF TEST ITEMS  
TO THE CRITICAL BEHAVIORS

- I. Formulating Problems and Hypotheses
  - A. Identifying and Exploring Problems
    - 2. INVESTIGATED UNEXPECTED RESULTS OR DIFFICULTIES  
ENCOUNTERED IN WORK.

This behavior seems to involve:

- (1) Knowing what to expect from a particular set of conditions
- (2) The ability to recognize that results found present a difficulty
- (3) The ability to recognize that the difficulty calls for some investigative action
- (4) The ability to develop hypotheses that might account for this difficulty
- (5) The ability to evaluate these hypotheses and select the one potentially most fruitful for investigation
- (6) Technical know-how and other skills to investigate the hypothesis

An item intended to predict this behavior:

Present a diagram of a heating system with some inconsistent data concerning it and list five aspects of the data which might reflect a difficulty. The examinee is asked to select that aspect which requires investigation. This should sample (1), (2), and (3) above.

Describe a situation which suggests that certain data need further investigation and list five possible methods of gaining information that might resolve the difficulty. The examinee is asked to select the most promising procedure. This should sample (3), (4), and (5) above.

- I. Formulating Problems and Hypotheses
  - A. Identifying and Exploring Problems
    - 4. SUGGESTED A NEW PROBLEM WHICH COULD BE STUDIED WITH AN  
ALREADY SUCCESSFUL TECHNIQUE.

This behavior seems to involve:

- (1) Familiarity with a technique that has already been used successfully
- (2) The ability to abstract a class of problems whose requirements would be fulfilled by that technique
- (3) The ability to select one problem from that class

An item intended to predict this behavior:

Describe a technique that has been used successfully and list several problems. The examinee is asked to select the problem for which the technique probably has most value. This should sample (2) and (3) above.

I. Formulating Problems and Hypotheses

B. Defining the Problem

3. GATHERED INFORMATION ON EXACT REQUIREMENTS, SPECIFICATIONS, AND GOAL OF ASSIGNED PROJECT.

This behavior seems to involve:

- (1) Recognizing the importance of gathering information
- (2) Identifying information required by problem
- (3) Taking steps to gather information
- (4) Taking these steps in proper order

An item intended to predict this behavior:

Describe a problem, present five elements of information that solution of problem may require, and ask examinee to select the one that would logically be sought first. This should sample (4) above.

Present a description of a problem and list five possible ways to begin solution of the problem. The examinee must select an essential step that must be taken first. This should sample (2) and (4) above.

Describe a planning conference that proved unproductive and list five possible criticisms of the session. The examinee is asked to recognize the need for more information in selecting the most important criticism of the session. This should sample (1) and (2) above.

I. Formulating Problems and Hypotheses

C. Setting Up Hypotheses

1. PROPOSED HYPOTHESIS OR GENERAL FORMULA IN ORDER TO EXPLAIN OBSERVED PHENOMENA.

This behavior seems to involve:

- (1) The ability to think of potential explanations of an observed event
- (2) The ability to evaluate the explanations
- (3) The ability to put the explanations in order of promise or practicability

An item intended to predict this behavior:

Present a description of an observed event and list five explanatory hypotheses, one of which is considerably less probable than the others, and require the examinee to select the least promising hypothesis; or present one promising and four poor hypotheses, requiring that the best be selected. Such an item would require the examinee to perform steps (2) and (3) above.

## I. Formulating Problems and Hypotheses

### C. Setting Up Hypotheses

2. PREDICTED PHENOMENA BY THEORETICAL OR MATHEMATICAL ANALYSIS.

This behavior seems to involve:

- (1) Searching for patterns or relationships in data
- (2) Developing or selecting a theoretical or mathematical analysis to account for the observed relationship(s)
- (3) Making a prediction on the basis of (2)

An item intended to predict this behavior:

Describe a relationship in a set of data and present a mathematical analysis that would account for the observed relationship. The examinee is asked to select from a list of predictions, the prediction that would follow from (2) above. This seems to sample (3) above.

## II. Planning and Designing the Investigation

### A. Collecting Background Information

1. SOUGHT OUT INFORMATION AND IDEAS FROM EXISTING LITERATURE, ASSOCIATES, OR EXPERTS ON PROBLEM BEFORE BEGINNING WORK ON PROJECT.

This behavior seems to involve:

- (1) Understanding that literature, associates, and experts may supply information that allows unnecessary work and errors to be avoided
- (2) Understanding that the sooner these sources are consulted, the less unnecessary work will be done and the fewer errors committed

An item intended to predict this behavior:

Describe a specific technical task to be performed. Indicate that the person who is to perform the task is unfamiliar with it. As alternatives offer various ways to begin work on the problem. Examinee is required to select consulting literature as preferable. This should sample (1) and (2) above.

## II. Planning and Designing the Investigation

### A. Collecting Background Information

2. INCLUDED ALL RELEVANT SOURCES IN SURVEYING LITERATURE OR CONSULTING EXPERTS.

This behavior seems to involve:

- (1) Recognition that as many relevant sources of information should be consulted as possible
- (2) The ability to think of sources relevant in a specific situation

An item intended to predict this behavior:

Describe a long research project and the steps taken to secure background information. A list of deficiencies in the work of the project is given and the examinee must recognize that all relevant sources were not consulted. This samples (1) and (2) above.

II. Planning and Designing the Investigation

A. Collecting Background Information

3. QUESTIONED THE VALIDITY OF MATERIAL IN THE LITERATURE.

This behavior seems to involve:

- (1) An objective attitude toward reported findings
- (2) Professional acumen sufficient to provide a background against which to consider material reported in the literature
- (3) The ability to weight appropriately the confidence to be placed in reported results and the expectations with which they are at variance

An item intended to predict this behavior:

Present a set of data from a very reliable source and also present very strong evidence that there is an obvious error in one datum. The examinee must recognize that the usually reliable source is not infallible and is probably in error in this case. This should sample (1), (2), and (3) above.

II. Planning and Designing the Investigation

A. Collecting Background Information

7. PERFORMED EXPERIMENT OR GATHERED NECESSARY INFORMATION DIRECTLY WHICH WAS UNAVAILABLE IN USUAL SOURCES.

This behavior seems to involve:

- (1) A strong and continuing desire to complete an assignment such as obtaining necessary information
- (2) A realization that consulting very unlikely sources may be less profitable than performing the necessary operations for obtaining the information directly
- (3) A willingness to perform necessary operations for obtaining information
- (4) The ability to perform necessary operations for obtaining information

An item intended to predict this behavior:

Specify a task of obtaining information and indicate that the usual sources have been consulted without success. List five possible steps that might be taken at that point. The examinee is asked to select a direct method of obtaining the information rather than either an indirect method or discontinuation of attempts at solution. This should sample (1) and (2) above.

II. Planning and Designing the Investigation  
B. SETTING UP ASSUMPTIONS

This behavior seems to involve:

- (1) The ability to formulate assumptions appropriate to the problem
- (2) The ability to examine assumptions critically
- (3) The ability to select assumptions appropriate to the problem on the basis of (2)

An item intended to predict this behavior:

Describe an experimental design and list five possible assumptions. Ask the examinee to select the assumption in the list that is necessary to the design. This should sample (2) and (3).

II. Planning and Designing the Investigation  
C. Identifying and Controlling Important Variables  
1. OUTLINED PLAN PERMITTING CONTROL AND SISTEMATIC VARIATION OF ALL RELEVANT VARIABLES.

This behavior seems to involve:

- (1) The ability to recognize relevant variables
- (2) The ability to decide which variables must be controlled in order to test a hypothesis adequately
- (3) The ability to devise methods to control the variables selected in (2)
- (4) The ability to integrate the materials in the development of a plan

An item intended to predict this behavior:

Describe an experiment where all relevant variables are not properly controlled. Present five alternatives offering different experimental designs, the correct choice being the one which best controls relevant variables. Ask the examinee to select the best plan; in doing so he must, in part, perform steps (1), (2), and (3).

Describe an experimental problem and list five possible plans for solving the problem. The examinee is asked to select the best design. This seems to sample (1) and (2) above.

Present a research problem and an outline of the planned steps. List five steps included and ask the examinee to select the step which is an example of good control of the variables. Or, list five steps and ask the examinee to select the step which is an example of poor control of the variables. This indirectly samples (1), (2), (3), and (4) above.

II. Planning and Designing the Investigation  
C. Identifying and Controlling Important Variables  
3. SIMULATED ACTUAL CONDITIONS IN A LABORATORY TEST

This behavior seems to involve:

- (1) Understanding of actual conditions
- (2) Knowledge of laboratory facilities
- (3) Appreciation of which conditions are important variables and which are not
- (4) Use of (2) to reproduce important conditions (3) in experiment
- (5) Organization of variables so that they may interact in all the ways they do under actual conditions

An item intended to predict this behavior:

Describe a testing problem in a laboratory situation. List five plans to test the material. The examinee is asked to select the plan which most closely simulates actual conditions. This should sample (1), (3), (4), and (5) in part.

Present a research problem and an outline of the planned steps. List five possible improvements of one step in the outline. The examinee is asked to select the best improvement. This should sample (3) and (5) above.

II. Planning and Designing the Investigation  
C. Identifying and Controlling Important Variables  
4. DESCRIBED OR OUTLINED PLANS IN WHICH THE VARIOUS FACTORS WERE TREATED IN ACCORDANCE WITH THEIR RELATIVE IMPORTANCE.

This behavior seems to involve:

- (1) Selecting experimental variables relevant to the problem
- (2) Judging their relative importance as related to criteria such as purpose of the investigation and practical applications to be made of results
- (3) Preparing a plan for the investigation that allots amount and type of data to be gathered for each variable in proportion to the judgments of importance made under (2)

An item intended to predict this behavior:

Present a research problem and an outline of the planned steps. List five of the steps and ask the examinee to select the step which reflects the most basic error in the design of the problem. This should sample (1), (2), and (3) above.

Present the details of a research problem and list five relevant variables. Ask the examinee to select the variable that is most likely to affect the outcome of the study. This should sample (2) above.

- II. Planning and Designing the Investigation  
C. Identifying and Controlling Important Variables  
5. POINTED OUT THE SIGNIFICANCE OF A FACTOR OVERLOOKED  
OR DISMISSED AS TRIVIAL BY OTHERS.

This behavior seems to involve:

- (1) An attitude that is critical of material until sufficient work has been done on it
- (2) The ability to recognize what factors would have a significant effect on results

An item intended to predict this behavior:

Describe an experimental design containing a critical uncontrolled variable and ask the examinee to discriminate that variable from less important variables. This should sample (2) above.

Describe an experimental design containing a critical uncontrolled variable and list five criticisms of the design. Ask the examinee to select the most important criticism of the design. This should sample (2) above.

- II. Planning and Designing the Investigation  
D. Developing Systematic and Inclusive Plans  
1. (Ineffective) OMITTED A RELEVANT FACTOR OR PHASE IN  
OUTLINING PLANS FOR AN INVESTIGATION.

This behavior seems to involve:

- (1) Carelessness in outlining plans although being aware of relevant factors and/or,
- (2) Failure to recognize relevance of factors or phases and/or,
- (3) Failure to consider relevant factors or phases and,
- (4) Inability or failure to review proposed plans critically.

An item intended to predict this behavior:

Present a set of instructions for the preparation of a chemical compound and list five necessary items for making the compound. The examinee is asked to select that item which is not sufficiently specific to prepare the compound. This should sample (2) and/or (3) above.

- II. Planning and Designing the Investigation  
D. Developing Systematic and Inclusive Plans  
3. POINTED OUT THE BASIC FACTORS IN A MASS OF INFORMATION  
ABOUT THE PROBLEM.

This behavior seems to involve:

- (1) The ability to formulate clearly the problem for which information is needed
- (2) The ability to judge the relevance of available information to the problem and to select the basic factors

An item intended to predict this behavior:

Present a situation in which a described report must be written and list five subjects for inclusion in the report. Ask the examinee to select the least useful subject. This should sample (1) and (2) above.

II. Planning and Designing the Investigation

D. Developing Systematic and Inclusive Plans

5. OUTLINED PLAN CALLING FOR EACH ELEMENT OF PROBLEM TO BE STUDIED IN SEQUENCE.

This behavior seems to involve:

- (1) Knowing or developing a definition of the problem
- (2) Selecting or developing a method appropriate to the problem
- (3) Outlining in detail steps involved in the method
- (4) Selecting the appropriate first step

An item intended to predict this behavior:

Describe a problem and offer as alternatives, steps that might be taken in various procedures. The examinee must select the step that would come first in the most appropriate method. This should sample (2) and (4).

II. Planning and Designing the Investigation

E. Developing Plans for the Use of Equipment, Materials, or Techniques

1. INCLUDED IN PLAN OF INVESTIGATION EQUIPMENT, MATERIAL, OR TECHNIQUES WHICH MET THE REQUIREMENTS OF THE PROBLEM.

This behavior seems to involve:

- (1) Identification of the requirements of the problem
- (2) The ability to relate pertinent characteristics of equipment, material, or techniques to the problem
- (3) The ability to evaluate these characteristics and to select those procedures that will best fulfill the requirements of the problem

An item intended to predict this behavior:

Describe a piece of equipment that does not meet certain specified requirements. List five possible ways of correcting the equipment in order to meet these requirements. The examinee must select the most satisfactory way to change the equipment or, ask the examinee to select the least satisfactory change. This should sample (2) and (3) above.

Describe the requirements of a problem and ask the examinee to select the technique that would best fulfill them. This should sample (2) and (3) above.

Describe a problem without making explicit its requirements. List five techniques that might resolve the problem and ask the examinee to select the best technique. Or, ask the examinee to select the least useful technique. This should sample (1), (2), and (3) above.

## II. Planning and Designing the Investigation

### E. Developing Plans for the Use of Equipment, Materials, or Techniques

#### 2. CHOSE A SIMPLIFIED TECHNIQUE THAT PRODUCED RESULTS OF REQUIRED STANDARDS.

This behavior seems to involve:

- (1) The ability to identify the standard required
- (2) Knowledge of several techniques that may or may not result in meeting the standard
- (3) The ability to evaluate (2) and to select the simplest technique that meets the standard

An item intended to predict this behavior:

Present a description of a problem and list five possible techniques to use in its solution. The examinee is asked to select the technique that is the simplest one that meets the standard. This seems to sample (1) and (3) above.

## II. Planning and Designing the Investigation

### E. Developing Plans for the Use of Equipment, Materials, or Techniques

#### 2. (Ineffective) PLANNED TO USE EQUIPMENT OR MATERIALS MORE COMPLEX OR EXPENSIVE THAN NECESSARY TO PRODUCE RESULTS OF REQUIRED STANDARDS.

This behavior seems to involve:

- (1) Lack of familiarity with existing equipment, materials, or techniques, and/or
- (2) Inability to evaluate these on the basis of cost or complexity, and/or
- (3) Failure to adapt equipment, materials, or techniques that are least expensive or most simple

An item intended to predict this behavior:

Present a diagram and description of an apparatus that is more complex or expensive than necessary for the specified standards. List five possible criticisms of the apparatus and ask the examinee to select the most pertinent criticism. This should sample (2) above.

## II. Planning and Designing the Investigation

### E. Developing Plans for the Use of Equipment, Materials, or Techniques

5. PLANNED TO USE TECHNIQUE OR EQUIPMENT THAT WOULD ELIMINATE DOUBT OF VALIDITY OR ACCURACY OF RESULTS.

This behavior seems to involve:

- (1) Concern for validity or accuracy of results
- (2) The ability to formulate the requirements of a problem that must be fulfilled in order to obtain valid or accurate results
- (3) the ability to devise or select techniques or equipment that will eliminate doubt of validity or accuracy

An item intended to predict this behavior:

Describe five instruments and their limits of accuracy. The examinee is asked to select the instrument that is most accurate. This seems to sample (3) above.

Present a research problem and an outline of its planned steps. Ask the examinee to select the best substitute for an inadequate step.

## II. Planning and Designing the Investigation

### E. Developing Plans for the Use of Equipment, Materials, or Techniques

7. CONDUCTED PILOT STUDY TO DETERMINE FEASIBILITY OF PROPOSED TECHNIQUES, MATERIALS, OR EQUIPMENT.

This behavior seems to involve:

- (1) The ability to recognize the importance of a pilot study before using a particular technique, material, or equipment
- (2) The ability to select that part of the problem which requires preliminary information before it can be put into effect
- (3) Technical know-how to conduct a pilot study
- (4) The ability to evaluate the results of the study in the light of desired objectives

An item intended to predict this behavior:

Describe a situation in which a problem is currently being studied. Ask the examinee to decide whether a new but untried technique should be used for the current problem. This should sample (1) above.

## II. Planning and Designing the Investigation

### F. Anticipating Difficulties

5. TOOK SPECIAL PRECAUTIONS IN PLANNING TO PREVENT DAMAGE TO EQUIPMENT.

This behavior seems to involve:

- (1) Personal attitude or outside pressure which demands that attempts be made to keep damage to equipment at a minimum
- (2) The ability to anticipate where damage might occur in particular equipment
- (3) The ability to think of and evaluate techniques that would reduce the possibility of such damage

An item intended to predict this behavior:

Illustrate and describe a piece of equipment and state that it is particularly susceptible to damage. Offer as alternatives various warnings to operators or changes in apparatus and require examinee to select the one most likely to decrease incidence of accidents to apparatus. This should sample (3) above.

## II. Planning and Designing the Investigation

### G. Determining the Number of Observations

1. OUTLINED PLAN OF INVESTIGATION WHICH PROVIDED FOR SUFFICIENT QUANTITY OF DATA TO BE TAKEN.

This behavior seems to involve:

- (1) Concern about whether or not data are sufficient
- (2) The ability to judge what would be sufficient or insufficient data for the problem at hand
- (3) Including the judgment made in (2) as a part of the plan of investigation

An item intended to predict this behavior:

Describe an experiment in which data insufficient as a basis for conclusions have been collected. Offer five alternatives, four of which indicate that data so far obtained are sufficient or more than sufficient. The fifth alternative should describe a program for the collection of necessary data in the most efficient manner.

## III. Conducting the Investigation

### A. Developing Methods, Materials, or Equipment

1. DEvised AN IMPROVED METHOD, MATERIAL, OR EQUIPMENT.

This behavior seems to involve:

- (1) The ability to detect a deficiency in existing methods, materials, or equipment.
- (2) A desire to correct the deficiency
- (3) The ability to analyze the source of the deficiency
- (4) A store of experience from which to develop possible corrections for the deficiency
- (5) The ability to evaluate these corrections in the light of (1) and (3), and to select the most appropriate correction

An item intended to predict this behavior:

Describe a piece of apparatus and the purpose it is to serve. Offer as alternatives changes in the apparatus and require examinee to select the change that would be of greatest value in accomplishing the purpose. This should sample (1), (3), and (5).

### III. Conducting the Investigation

#### A. Developing Methods, Materials, or Equipment

1. (Ineffective) DEVELOPED A NEW METHOD WHEN APPROPRIATE ONE EXISTED.

This behavior seems to involve:

- (1) Recognition of a problem
- (2) A lack of knowledge of existing methods appropriate to the solution of the problem and/or
- (3) A poor evaluation of the worth of appropriate existing methods for the solution of the problem and/or
- (4) A failure to recognize the cost in time and money involved in instituting new methods.

An item intended to predict this behavior:

Describe a problem that requires a piece of equipment with certain specifications. Present five pieces of equipment in diagram form. Two of these would fulfill the specifications but one must be specially constructed. Ask the examinee to select the most appropriate. This should sample (3) or (4) above.

### III. Conducting the Investigation

#### B. Applying Methods and Techniques

1. USED A TECHNIQUE, MATERIAL, OR EQUIPMENT WHICH SOLVED PROBLEM OR ELIMINATED DIFFICULTY IN THE INVESTIGATION.

This behavior seems to involve:

- (1) The ability to think of possible techniques to solve the problem
- (2) The ability to predict the consequences of the techniques available
- (3) The ability to select the most appropriate technique for the purpose

An item intended to predict this behavior:

Describe a problem concerning the use of a particular instrument or technique. Ask the examinee to select from a list of five procedures the one that would best solve the problem.

### III. Conducting the Investigation

#### B. Applying Methods and Techniques

2. POINTED OUT THAT METHOD OR DEVICE DID NOT MEET THE REQUIREMENTS OF THE INVESTIGATION.

This behavior seems to involve:

- (1) The ability to identify the requirements of the problem
- (2) The ability to evaluate methods and devices with respect to the requirements of the problem and thus identify which are appropriate and which inappropriate

An item intended to predict this behavior:

Present a detailed description of equipment and its use. Ask examinee to select the chief disadvantage of the equipment for this use. This should sample (1) and (2) above.

III. Conducting the Investigation

B. Applying Methods and Techniques

3. SUBSTITUTED A METHOD, TECHNIQUE, OR EQUIPMENT GIVING RESULTS BETTER THAN THE ONE IN CURRENT USE.

This behavior seems to involve:

- (1) A familiarity with existing methods, techniques, or equipment
- (2) The ability to detect weaknesses in current techniques
- (3) The ability to think up and evaluate possible substitutes for (1)

An item intended to predict this behavior:

Describe a common measurement problem and list five possible but unconventional techniques for its solution. Ask the examinee to select the best technique. This should sample (3) above.

III. Conducting the Investigation

B. Applying Methods and Techniques

4. USED SUBSTITUTE MATERIAL OR SIMPLIFIED PROCEDURE THAT MET STANDARDS AND SAVED MONEY AND TIME.

This behavior seems to involve:

- (1) Recognizing that there are defects in present materials or procedures
- (2) Thinking of ways to eliminate or lessen the effect of these defects
- (3) Evaluating these substitute materials or procedures in the light of the standards of the problem
- (4) Selecting the most appropriate

An item intended to predict this behavior:

Describe the characteristics of five different materials. Describe a situation in which one of the materials could best be used, resulting in economy of time or funds. Ask the examinee to select the material that would be most appropriate. This should sample (3) and (4) above.

III. Conducting the Investigation

B. Applying Methods and Techniques

8. TAUGHT HIMSELF TO OPERATE EQUIPMENT WITHOUT SUPERVISION.

This behavior seems to involve:

The ability to deduce the operating principles of a piece of equipment on the basis of minimal cues, such as examination of the equipment itself, study of operating manuals, or a knowledge of the operation of similar equipment.

An item intended to predict this behavior:

Present a detailed diagram of a piece of equipment and a general statement of its function. List five possible steps in operating the equipment that could be taken. Ask the examinee to select the first step in operating the equipment. This should sample the above.

III. Conducting the Investigation

C. Modifying Planned Procedures

6. ANTICIPATED THE PROBABLE EFFECT OF A DEFECT OR DIFFICULTY AND TOOK APPROPRIATE ACTION.

This behavior seems to involve:

- (1) The ability to foresee possible difficulties
- (2) Taking an inventory of available procedures which might remedy the defect
- (3) Selecting the remedy that will provide the most satisfactory solution

An item intended to predict this behavior:

Describe a situation in which a defect is developing and offer as alternatives an inventory of available materials or procedures. Examinee must select alternative that will provide the best remedial effect when properly applied.

III. Conducting the Investigation

D. APPLYING THEORY

This behavior seems to involve:

- (1) The ability to understand thoroughly a scientific generalization
- (2) The ability to recognize a specific example of the generalization
- (3) The behaviors reported in the list of critical requirements under III-D

An item intended to predict this behavior:

Illustrate a scientific generalization by example and imply the principle involved. List five possible illustrations of the generalization and ask the examinee to select the one which is not illustrative of the principle. This should sample (1) and (2) above.

III. Conducting the Investigation

D. Applying Theory

1. PERFORMED AN UNFAMILIAR CALCULATION OR OPERATION WITHOUT INSTRUCTION.

This behavior seems to involve:

- (1) The ability to assimilate new information about an unfamiliar calculation or operation
- (2) The ability to apply this new information according to rules peculiar to the calculation or operation

An item intended to predict this behavior:

Supply a series of rules concerning an unfamiliar mathematical system. Ask the examinee to use these rules in the solution of a series of problems. This should sample (1) and (2) above.

III. Conducting the Investigation

D. Applying Theory

2. MADE AN APPLICATION OF NEW OR COMPLEX MATERIAL TO OWN WORK AFTER BRIEF EXPLANATION.

This behavior seems to involve:

- (1) The ability to understand new or complex material
- (2) The ability to perceive the relationships between the new or complex material and other problems
- (3) The ability to apply (2) to the solution of a problem

An item intended to predict this behavior:

Describe a set of symbols and present statements concerning their relationships. Ask the examinee to apply this material in the solution of a series of problems. This should sample (1), (2), and (3) above.

III. Conducting the Investigation

D. Applying Theory

4. TRANSFORMED PHYSICAL PROBLEM SO THAT IT COULD BE SOLVED BY MATHEMATICAL ANALYSIS.

This behavior seems to involve:

- (1) The ability to recognize when a mathematical representation of a problem is desirable
- (2) The ability to recognize which aspects of a problem are susceptible to mathematical analysis
- (3) The ability to make this transformation

An item intended to predict this behavior:

Describe the variables of a problem and list five possible ways of representing these variables. Ask the examinee to select the kind of representation that best fits the problem. This should sample (1) above.

III. Conducting the Investigation

D. Applying Theory

6. DETERMINED THE PURPOSE OR OPERATION OF A DEVICE BY STUDYING ITS CONSTRUCTION.

This behavior seems to involve:

- (1) Application of knowledge of mechanical principles - for example, relating knowledge of parts of similar devices to new situation and hypothesizing about functions of parts
- (2) Testing of hypotheses by physical or mental manipulations of parts
- (3) Organizing conclusions about functions of parts to deduce function of apparatus as a whole

- (4) Selecting possible applications related to the function and judging practicality of the apparatus for each such purpose

An item intended to predict this behavior:

Present a diagram of an apparatus and describe its parts. List five possible uses of the apparatus and ask the examinee to select the use for which the apparatus is best suited. This should sample (3) and (4) above.

### III. Conducting the Investigation

#### E. Attending to and Checking Details

1. FOLLOWED ALL ESSENTIAL DETAILS OF PRESCRIBED PROCEDURES FOR A ROUTINE OPERATION.

This behavior seems to involve:

- (1) A recognition of which details of prescribed procedures are essential, or
- (2) A practice of following prescribed procedures letter for letter

An item intended to predict this behavior:

Describe a procedure for a simple experiment and ask the examinee to select an unessential detail. This should sample (1) above.

### III. Conducting the Investigation

#### E. Attending to and Checking Details

3. HANDED IN WORK ONLY AFTER HE HAD CHECKED IT.

This behavior seems to involve:

- (1) Concern about accuracy
- (2) Willingness to undertake the extra labor involved in checking results

An item intended to predict this behavior:

Present partially completed calculations of experimental results that contain an error. Ask the examinee to select the value to be reported. This should sample (1) and (2) above.

### III. Conducting the Investigation

#### F. ANALYZING THE DATA

This behavior seems to involve:

- (1) Information about techniques available and their applicability to various situations
- (2) Knowledge of how to apply these techniques

An item intended to predict this behavior:

Present data from an investigation, and offer as alternatives simple ways of analyzing data; have examinee select the most appropriate one. This should sample (1) and (2) above.

#### IV. Interpreting Research Results

##### A. Evaluating Findings

##### 1. PRODUCED CONCLUSIONS OR RECOMMENDATIONS SUPPORTED BY DATA.

This behavior seems to involve:

- (1) A point of view that prevents hasty selection of conclusions
- (2) The ability to analyze a set of data
- (3) The ability to apply logical principles
- (4) The ability to draw the correct conclusion and not to accept conclusions unsupported by the data

An item intended to predict this behavior:

Describe an experimental procedure and the results obtained. List five possible conclusions and ask the examinee to select the conclusion supported by the data. This should sample (1), (2), (3) and (4) above.

#### IV. Interpreting Research Results

##### A. Evaluating Findings

##### 2. DREW CONCLUSIONS IN ACCORDANCE WITH CORRECT LOGICAL PRINCIPLES.

This behavior seems to involve:

- (1) The ability to understand what is involved in a set of data or propositions
- (2) The ability to recognize what is and is not necessarily implied by these data or propositions, or
- (3) The ability to formulate a valid generalization from these data or propositions

An item intended to predict this behavior:

Present a proposition and list five implications of the proposition. Ask the examinee to select an implication that necessarily follows from the proposition. This should sample (1) and (2) above.

Present a series of propositions expressing relationships among a set of variables. Ask the examinee to solve several problems by logical manipulation of these propositions. This should sample (1) and (2) above.

#### IV. Interpreting Research Results

##### A. Evaluating Findings

##### 5. POINTED OUT WHETHER OR NOT THE EVIDENCE WAS CONCLUSIVE.

This behavior seems to involve:

- (1) The ability to judge relevance of the evidence to the conclusions drawn
- (2) The ability to evaluate the conclusiveness of the evidence

An item intended to predict this behavior:

Describe an experimental problem, its design, and the results obtained. List several possible conclusions and ask the examinee to judge whether or not the evidence clearly justifies each conclusion. This should sample (1) and (2) above.

IV. Interpreting Research Results

A. Evaluating Findings

6. POINTED OUT THE LIMITATIONS OF DATA OR METHOD,  
INCLUDING CONFLICTING ELEMENTS.

This behavior seems to involve:

- (1) The ability to recognize what requirements must be met before conclusions can be drawn
- (2) The ability to recognize when these requirements have been met and when they have not
- (3) The ability to detect inconsistencies in data

An item intended to predict this behavior:

Describes a problem and present data inadequate for its solution. Give the examinee the opportunity to select a conclusion based on inadequate data or to recognize the inadequacy. This should sample (1) and (2) above.

Describe an experimental procedure and the results obtained. Ask the examinee to result that is inconsistent with a particular condition of the experiment. This should sample (3) above.

IV. Interpreting Research Results

B. Pointing Out Implications of Data

2. WORKED OUT APPLICATIONS TO OTHER PROBLEMS OR FIELDS.

This behavior seems to involve:

- (1) Knowledge of the nature of related problems in the same field or in related fields; this includes a general knowledge of the variables, current findings, and theories relative to such problems
- (2) The ability to perceive relationships between results of a current problem and related problems

An item intended to predict this behavior:

Present findings that may be expected to have considerable effect in a number of fields. Ask examinee to choose field in which effect will be least.

Present a description of five materials and ask the examinee which material would be best applied in specific related fields. This should sample (1) and (2) above.

V. Preparing Reports

A. DESCRIBING AND ILLUSTRATING WORK

This behavior seems to involve:

- (1) The ability to recognize the importance of certain factors in describing and illustrating work, for example, clarity and conciseness
- (2) The ability to achieve these factors
- (3) The ability to judge when these factors have been achieved

An item intended to predict this behavior:

Describe an experiment and present five alternative ways of stating findings. Only one of these statements should meet standards for conciseness and brevity. Selecting this alternative should demonstrate (1) and (3) above.

V. Preparing Reports

A. Describing and Illustrating Work

2. (Ineffective) GAVE EXCESSIVE DETAIL IN DESCRIPTIVE MATERIAL.

This behavior seems to involve:

- (1) An inability to determine which details are pertinent to the objectives of a specific report and which are not, and/or
- (2) A desire to "pad" the report

An item intended to predict this behavior:

Present an excessively detailed paragraph taken from a scientific report. List five possible criticisms of the paragraph and ask the examinee to select the most pertinent. This should sample (1) above.

V. Preparing Reports

A. Describing and Illustrating Work

6. USED GRAPHIC, TABULAR, OR PICTORIAL MATERIAL TO CLARIFY TEXT.

This behavior seems to involve:

- (1) Recognizing the value of illustrative material in clarifying text
- (2) Recognizing which type of illustrative material is most appropriate for particular data

An item intended to predict this behavior:

Present a list of five types of data and ask the examinee to select the one which would most appropriately be presented in graphic form in a research report. This should sample (2) above.

V. Preparing Reports

B. Substantiating Procedures and Findings

2. DESCRIBED ALL SIGNIFICANT ELEMENTS OF EXPERIMENT, CONDITIONS, AND RESULTS.

This behavior seems to involve:

- (1) An understanding that a report is a history of an experiment and that information having any bearing on the experiment is a necessary inclusion in the report.
- (2) An understanding that the report serves two main purposes: (a) communicates findings; (b) allows repetition of his work (and warns of unprofitable procedures).

An item intended to predict this behavior:

Present five alternative organizations of a research report and ask the examinee to select the most appropriate one. This should sample (1) and (2) above.

Describe all the results of an experiment and ask the examinee to select the results that should be reported. This should sample (1) and (2) above.

V. Preparing Reports

B. Substantiating Procedures and Findings

4. (Ineffective) OMITTED DETAILS NECESSARY FOR APPLICATION OR CHECKING OF WORK.

This behavior seems to involve:

Recognition of the necessity of including in a report details sufficient for others to apply or to check the work.

An item intended to predict this behavior:

Present a portion of a report that fails to report the methods used in obtaining certain results and list criticisms that might be applied to the report. Ask the examinee to select the most appropriate criticism. This should sample, in part, the behavior described above.

V. Preparing Reports

C. ORGANIZING THE REPORT

This behavior seems to involve:

- (1) A realization that information necessary to the understanding of other sections of the report should, in general, precede them
- (2) A realization that the steps in procedures should be reported in the order in which they were taken

An item intended to predict this behavior:

Present a poorly organized paragraph taken from a scientific report. Ask the examinee to select the most appropriate criticism of the paragraph. This should sample (1) and (2) above.

V. Preparing Reports

C. Organizing the Report

7. PLACED LENGTHY OR DETAILED ANALYSIS OR DATA IN APPENDIX.

This behavior seems to involve:

- (1) Knowledge of standard practice in organizing research reports
- (2) Understanding of the relative advantages of alternative ways of organizing reports

An item intended to predict this behavior:

Present five kinds of material to be included in a report, several of which might be placed in an appendix. The examinee would demonstrate (1) and (2) by selecting the kind of material that most clearly belongs in the appendix.

V. Preparing Reports

D. Using Appropriate Style in Presenting Report

1. USED A STYLE ADAPTED TO AUDIENCE OR READERS.

This behavior seems to involve:

- (1) An appreciation of the styles of composition appropriate to specific audiences
- (2) An ability to use the appropriate style

An item intended to predict this behavior:

Present an inappropriately informal paragraph taken from a scientific report. Ask the examinee to select the most appropriate criticism of the paragraph. This should sample (1) above.

VI. Administering Research Projects

A. Selecting and Training Personnel

2. ASSIGNED WORKER A PROJECT SUITING ABILITY OR TRAINING.

This behavior seems to involve:

- (1) Obtaining sufficient information about the requirements of the job
- (2) Procuring sufficient information about the skills and interests of available personnel
- (3) Assigning personnel to specific projects on the basis of information obtained in (1) and (2)

An item intended to predict this behavior:

Describe some qualifications of personnel available for job. Also describe some job requirements. Examinee should base choice on fact that neither type of information is sufficiently detailed for use as a basis for assignment of best worker to the job.

Describe the duties of a particular position and list five different levels of training. Ask the examinee to select the level of training necessary for the job. This should sample (3) above.

VI. Administering Research Projects

A. Selecting and Training Personnel

7. MADE SUGGESTIONS TO SUBORDINATES ONLY AFTER LEARNING DETAILS.

This behavior seems to involve:

- (1) A preference for familiarizing oneself with relevant information before making a decision or suggestion
- (2) The ability to use this preference in an appropriate situation

An item intended to predict this behavior:

Describe a situation in which a suggestion might be made immediately. Offer alternatives which require the examinee to decide whether a suggestion should be made immediately or whether more information is necessary. This should sample (1) and (2) above.

VI. Administering Research Projects

B. Dealing With Subordinates

a. ADMINISTERING REPRIMANDS, RECOGNITION, AND PRAISE.

This behavior seems to involve:

- (1) An ability to decide objectively whether reprimand, recognition, or praise is called for
- (2) An ability to devise an appropriate reprimand, recognition, or praise
- (3) Administering (2)

An item intended to predict this behavior:

Describe a situation in which a subordinate has been guilty of unethical behavior. Offer, as alternatives, methods of dealing with the man. Require examinee to select the alternative that would be most appropriate to the offense and would do most to preserve morale of other workers. This would sample (2) above.

Describe a situation in which an unwarranted reprimand has been administered. List five possible actions that could be taken. Ask the examinee to select the most appropriate action. This should sample, in part, (1) and (2) above.

VI. Administering Research Projects

B. Dealing With Subordinates

b. LOOKING OUT FOR SUBORDINATES' WELFARE.

This behavior seems to involve:

- (1) A point of view that demands concern about the welfare of all subordinates
- (2) The ability to take administrative actions which provide for the welfare of subordinates

An item intended to predict this behavior:

Describe a situation in which an administrative decision affecting the welfare of subordinates must be made. List five possible decisions and ask the examinee to select the most appropriate decision. This should sample (1) and (2) above.

- VI. Administering Research Projects
  - B. Dealing With Subordinates
    - b. Looking Out for Subordinates' Welfare
      - 1. ARRANGED A SCHEDULE ACCEPTABLE TO SUBORDINATES

This behavior seems to involve:

- (1) Recognition that the convenience and satisfaction of subordinates should be considered in arranging a work schedule
- (2) Choosing or adopting a schedule compatible with subordinates' convenience as far as possible in a specific situation

An item intended to predict this behavior:

Describe a situation in which an administrative decision affecting the schedule of a subordinate must be made. List five possible decisions and ask the examinee to select the most appropriate decision. This should sample (1) and (2) above.

- VI. Administering Research Projects
  - B. Dealing With Subordinates
    - d. Sharing Responsibility
      - 2. ASKED FOR OR ACCEPTED SUBORDINATES' IDEAS.

This behavior seems to involve:

- (1) A recognition that subordinates may contribute substantially to the solution of a technical problem
- (2) A willingness to consider subordinates' suggestions in specific situations
- (3) A positive effort to solicit the suggestions of subordinates

An item intended to predict this behavior:

Describe a situation in which a technical decision in the planning of a research project is to be made and state the action taken by the administrator. The examinee is asked to select the action he would take in the situation. This should sample (1), (2) and (3) above.

- VI. Administering Research Projects
  - C. Planning and Coordinating the Work of Groups
    - b. Estimating and Supplying Project Needs
      - 1. OUTLINED AND SCHEDULED PERSONNEL NEEDS.

This behavior seems to involve:

- (1) The ability to prepare a detailed plan which includes a breakdown of steps involved in the total project, working hours required, and the number and type of personnel needed for each step
- (2) The ability to translate these plans into a working schedule, assigning available personnel to specific units of work throughout all phases of the schedule
- (3) The ability to revise the schedule as demanded by current personnel needs

An item intended to predict this behavior:

Describe a situation which requires a revision in the work schedule for a research project. List five possible actions and ask the examinee to select the most appropriate action. This should sample (3) above.

VI. Administering Research Projects

C. Planning and Coordinating the Work of Groups

b. Estimating and Supplying Project Needs

3. FAILED TO REQUEST FACILITIES VIA PROPER CHANNELS.

This behavior seems to involve:

- (1) Not knowing the proper channels through which to request facilities
- (2) In the event that these channels are not made explicit, being unable to decide upon the most appropriate channels through the use of social skills

An item intended to predict this behavior:

Describe a situation in which facilities must be requested, and list five alternative approaches for making the request. Ask the examinee to select the most appropriate action. This should sample (2) above.

VI. Administering Research Projects

C. Planning and Coordinating the Work of Groups

c. ORGANIZING THE WORK OF PROJECTS.

This behavior seems to involve:

- (1) Familiarity with the over-all purposes of the research program
- (2) The ability to evaluate the contributions of individual projects or phases of projects to these purposes
- (3) The ability to assign appropriate priorities to them on the basis of (1) and (2)

An item intended to predict this behavior:

Describe a research program and list its various phases. Ask the examinee which phases are to receive the most, and which the least, priority. This should sample (2) and (3) above.

VI. Administering Research Projects

C. Planning and Coordinating the Work of Groups

d. UNIFYING RELATED GROUPS.

This behavior seems to involve:

- (1) Recognition of the importance of unifying the work of related groups
- (2) information and techniques necessary to effect a functional unification

An item intended to predict this behavior:

Describe a situation in which an administrator must select a policy involving techniques to coordinate the work of several divisions in a laboratory. List five policies and ask the examinee to select the policy that fills the purpose most adequately. This should sample (1) and (2) above.

VI. Administering Research Projects

D. MAKING ADMINISTRATIVE DECISIONS

This behavior seems to involve:

- (1) Making decisions when necessary
- (2) Deciding on the basis of regulations in force and the problem at hand
- (3) Arriving at the best decision possible

An item intended to predict this behavior:

Describe a situation in which an administrative decision must be made and list five possible decisions. Ask the examinee to select the most appropriate one. This should sample (1), (2), and (3) above.

VI. Administering Research Projects

D. Making Administrative Decisions

b. Following Regulations in Decisions

1. DEVIATED FROM STANDARD ADMINISTRATIVE PROCEDURE TO HANDLE EMERGENCY.

This behavior seems to involve:

- (1) Familiarity with standard administrative procedure
- (2) The ability to recognize an emergency situation
- (3) The ability to make a judgment that the situation requires deviation from standard procedure

An item intended to predict this behavior:

Describe a particular emergency situation in which an administrative decision must be made. Present alternative decisions, one of which calls for deviation from standard procedure to handle the emergency. In selecting this choice, the examinee must perform steps (2) and (3).

VI. Administering Research Projects

D. Making Administrative Decisions

c. Basing Decisions on Facts

1. DECIDED ONLY AFTER GATHERING ALL PERTINENT FACTS.

This behavior seems to involve:

- (1) An attitude of suspending judgment where possible until sufficient information is available
- (2) Making decision to gather needed facts in specific situations

An item intended to predict this behavior:

Describe a situation in which the work of two groups is not adequately coordinated. Give the examinee the opportunity to make a decision concerning the two groups on insufficient information or to suspend judgment. This should sample (1) above.

VI. Administering Research Projects

E. Working With Other Groups

2. GOT OPPOSING GROUPS TO AGREE

This behavior seems to involve:

- (1) The ability and desire to be tactful
- (2) The ability and desire to be persuasive
- (3) Fairness

An item intended to predict this behavior:

Describe a situation in which two groups are in disagreement; present alternative courses of action in handling the situation, the best choice giving the most opportunity for (1) and (2) to be exercised.

VII. Accepting Organizational Responsibility

A. Performing Own Work

b. Accepting Responsibility for Own Work

4. (Ineffective) LEFT INCOMPLETE WORK IN SUCH CONDITION THAT OTHERS COULD NOT COMPLETE IT.

This behavior seems to involve:

- (1) The lack of a point of view that holds the goals of the research over other more personal goals and/or
- (2) The inability to recognize that leaving work in a condition permitting others to carry it on benefits the over-all goals of the research

An item intended to predict this behavior:

Place an individual in the position of leaving a project and ask him to select the action with highest priority for the limited time remaining, i.e., preparing to leave his work so that successor may continue it most efficiently.

VII. Accepting Organizational Responsibility

A. Performing Own Work

c. Allocating Own Time and Effort

3. TOOK ON ADDITIONAL WORK VOLUNTARILY

This behavior seems to involve:

- (1) A positive attitude toward the achievement of the central goal of a work program
- (2) An understanding or correct identification of the central goal of a work program
- (3) A willingness to undertake additional work in an effort to achieve the central goal

An item intended to predict this behavior:

Describe a work program in which an administrative decision must be reached concerning a man who took on additional work. List five possible decisions and ask the examinee to select the most appropriate one. This should sample (1) and (2) above.

VII. Accepting Organizational Responsibility

A. Performing Own Work

c. Allocating Own Time and Effort

3. (Ineffective) SPENT TIME DOING MORE WORK ON AN ASSIGNMENT THAN DESIRABLE CONSIDERING THE NATURE OF THE ASSIGNMENT.

This behavior seems to involve:

- (1) The inability to understand or a failure to define the central goal of a particular assignment, and/or
- (2) The inability to keep the central goals of the research as the primary criterion of quality and quantity of work desired

An item intended to predict this behavior:

Describe a situation in which a decision must be made concerning allocation of time and effort and list five possible directions toward which to allocate time. Ask the examinee to select the most appropriate. This should sample (1) and (2) above.

VII. Accepting Organizational Responsibility

A. Performing Own Work

c. Allocating Own Time and Effort

4. ORGANIZED WORK TO PERMIT CARRYING OUT SEVERAL DIFFERENT TASKS CONCURRENTLY.

This behavior seems to involve:

- (1) The ability to work at high efficiency, which seems to involve
  - (a) Making motions serve as many desired purposes as possible
  - (b) Doing no more than proper prosecution of task requires
- (2) The desire to work efficiently

An item intended to predict this behavior:

Describe a situation in which a job must be organized in the most efficient manner and list five possible ways of organizing the job. Ask the examinee to select the most efficient way of doing the job. This should sample (1) above.

VII. Accepting Organizational Responsibility

B. Assisting in the Work of Others

3. KEPT INTERESTED PERSONS AND GROUPS FULLY INFORMED ON PROGRESS OF PROJECT.

This behavior seems to involve:

- (1) Understanding of the purpose of reporting on progress regularly
- (2) The ability to utilize appropriate techniques for reporting on progress
- (3) Concern for keeping others informed

An item intended to predict this behavior:

Describe a situation in which the writing of a progress report is considered and in which an objection is raised to writing the report. List five possible criticisms of the objection and ask the examinee to select the most pertinent criticism. This should sample (1) above.

VII. Accepting Organizational Responsibility

B. Assisting in the Work of Others

6. POINTED OUT INADEQUACIES OF A PLAN, REGULATION, OR POLICY TO GROUP RESPONSIBLE FOR IT.

This behavior seems to involve:

- (1) The ability to recognize that a plan, regulation, or policy is inadequate in certain respects
- (2) The recognition that something should be done to remedy the inadequacy
- (3) The recognition that it is usually most desirable to approach those responsible for the inadequacy first

An item intended to predict this behavior:

Describe a situation in which a plan for coordinating the work of two groups is not working efficiently, since the work of one group is being delayed by the other group. List several actions that the head of the former group might take, one of which is to confer with the head of the slow group. Ask the examinee to select the most appropriate action. This should sample, in part, (1), (2), and (3) above.

VII. Accepting Organizational Responsibility

C. SUBORDINATING PERSONAL INTERESTS

This behavior seems to involve:

- (1) The understanding of the central goals of a work program
- (2) The recognition that, in addition to one's own interests, the interests or ideas of others might be of value in achieving the central goals of a work program.

An item intended to predict this behavior:

Describe a situation in which a decision must be made concerning the planning of the direction in which work of a project will go. List five possible decisions and ask the examinee to decide whether it is advisable to subordinate the central goals of the project to the supervisor's interests. This should sample (1), and (2) ~~in-~~ directly.

VII. Accepting Organizational Responsibility

D. Accepting Regulations and Supervision

1. REQUESTED CLARIFICATION OF ASSIGNMENT WHEN DOUBT.

This behavior seems to involve:

The ability to recognize when a situation is ambiguous and demands clarification

An item intended to predict this behavior:

Describe an ambiguous situation and require the examinee to recognize it as such, by choosing a course of action that will lead to clarification. This should sample the above.

VII. Accepting Organizational Responsibility

D. Accepting Regulations and Supervision

2. SOLICITED AID FROM SUPERIOR WHEN FACED WITH DIFFICULTIES.

This behavior seems to involve:

- (1) Recognizing a situation that individual is not capable of coping with alone
- (2) Realizing that it is most effective to request aid immediately without wasting time

An item intended to predict this behavior:

Describe a situation calling for a decision that an individual is not capable of making. From five possible lines of action, the examinee must select the one that suggests asking for help from a superior. In doing so, the examinee must perform (1) and (2) above.

VIII. Accepting Personal Responsibility

A. Adapting to Associates

1. CRITICIZED THE WORK OF ANOTHER WITHOUT DISPARAGING HIS EFFORTS.

This behavior seems to involve:

- (1) A recognition that the feelings (egos) of others are involved in their work, and that individuals perform better if they are not personally criticized
- (2) The ability to offer a criticism or suggestion tactfully through such techniques as (a) first discussing the problem to learn the individual's general approach, knowledge, and opinions about the problem, and (b) bringing in the criticism or suggestion at an appropriate time and in a tactful manner

An item intended to predict this behavior:

Present a situation in which the work done by one staff member has definite shortcomings. Allow examinee to decide whether or not he, as a co-worker, would criticize the work of the other, and if so, whether he would select the choice describing a criticism least calculated to belittle the other.

VIII. Accepting Personal Responsibility

A. Adapting to Associates

4. (Ineffective) QUARRELLED WITH OR SPOKE RUDELY TO OTHER STAFF MEMBERS

This behavior seems to involve:

- (1) The failure to recognize the importance of maintaining amicable relationships with other staff members, and/or
- (2) The inability to control one's behavior so that it is compatible with maintaining amicable relationships.

An item intended to predict this behavior:

Describe a situation in which one of the staff members is unnecessarily rude to another member of the staff. List five other courses of action and ask the examinee to select the most appropriate one. This should sample (1) above.

VIII. Accepting Personal Responsibility

B. Adapting to Job Demands

2. CONTINUED TO WORK ACCORDING TO PLAN IN SPITE OF OBSTACLES OR OPPOSITION.

This behavior seems to involve:

- (1) A continuing strong conviction that the plan of a particular piece of work is the best available for that work
- (2) The skills necessary to act on that conviction in the face of opposition
- (3) The ability to avoid being dissuaded from fulfilling that conviction

An item intended to predict this behavior:

Describe a situation in which a man is convinced that his present way of attacking a problem is the plan that should be followed; also describe various obstacles to fulfilling the plan. The examinee must choose to continue with the plan when offered five choices of action to be taken.

VIII. Accepting Personal Responsibility  
C. MEETING PERSONAL COMMITMENTS

This behavior seems to involve:

- (1) Concern for meeting commitments
- (2) Willingness to put forth considerable effort in order to meet commitments
- (3) Acceptance of responsibility for failure to meet commitments and/or efforts to take the "next best" course

An item intended to predict this behavior:

Describe a situation in which there is a failure to meet a commitment. List five possible ways of reducing the seriousness of the failure and ask the examinee to select the most effective way. This should sample (3) above.

VIII. Accepting Personal Responsibility  
C. Meeting Personal Commitments

1. (Ineffective) FAILED TO PERFORM A SPECIFICALLY ASSIGNED TASK TO WHICH HE HAD AGREED.

This behavior seems to involve:

- (1) Concern for meeting commitments
- (2) Willingness to put forth considerable effort in order to meet commitments

An item intended to predict this behavior:

Describe a situation in which an individual has made a commitment but finds that he will have considerable difficulty in meeting it. A list of alternative lines of action is presented. The examinee should choose the alternative indicating that the individual will meet his commitment even though it involves personal inconvenience. In order to prevent the item from being too obvious the correct answer is limited to only a part of what is considered to be the best action in this situation. This should sample (1) and (2) above.

VIII. Accepting Personal Responsibility  
D. BEING FAIR AND ETHICAL

This behavior seems to involve:

- (1) Considering or presenting all evidence objectively
- (2) Being truthful in all communications
- (3) Giving credit where credit is due
- (4) Taking responsibility for own actions

An item intended to predict this behavior:

Describe a situation where criticism may be expected if (1) is done; examinee must recognize that (1) is nevertheless necessary. This recognition of the necessary action does not, of course, assure that the examinee would actually perform comparable behavior.

Describe a situation in which an error has been committed and list five possible reasons offered by the individual who made the error. Ask the examinee to select the most ethical reason. This should sample (4) above.

VIII. Accepting Personal Responsibility

D. Being Fair and Ethical

2. GAVE CREDIT FOR IDEAS OR WORK TO THOSE RESPONSIBLE.

This behavior seems to involve:

- (1) A concern for fair distribution of credit for ideas or other work
- (2) A recognition that all who had a responsible part in a project should be given credit

An item intended to predict this behavior:

Describe a situation in which an administrative policy must be set concerning distribution of credit for work. List five possible policies and ask the examinee to select the most ethical policy. This should sample (1) and (2) above.

VIII. Accepting Personal Responsibility

E. Showing Interest in Work

1. WORKED ON OWN TIME TO IMPROVE TECHNICAL KNOWLEDGE AND PROFICIENCY.

This behavior seems to involve:

A strong interest in and desire to learn more about one's work

An item intended to predict this behavior:

Describe briefly the work of a group of five research workers concerned with the same project. Include in the description the actions of each which might indicate interest in the work, the action of one being extensive study of material related to the problem on his own time. The actions of the others should be less outstanding. Ask the examinee to evaluate the men by selecting the one who the evidence suggests would be the most desirable worker. The item would measure recognition of the value of personal effort to improve own technical knowledge and proficiency.

VIII. Accepting Personal Responsibility

E. Showing Interest in Work

4. ASKED SUBORDINATES TO EDUCATE HIM BY EXPLAINING THEIR WORK IN DETAIL.

This behavior seems to involve:

- (1) A strong interest in one's work
- (2) A recognition that a subordinate, by a detailed explanation of his work, might be able to add to the information of a supervisor

An item intended to predict this behavior:

Describe a situation in which a supervisor asks a subordinate to report on the details of his work. The examinee is asked to evaluate this action. This should sample (2) above.

## Appendix IV

### DISTRIBUTIONS OF RESPONSES FOR EACH ITEM OF THE FINAL TRYOUT FORMS

Appendix IV contains tabulations of the number of examinees selecting each response for final tryout forms of test items. Examinees included those groups described in the project report for the final tryouts held at the University of Pittsburgh and Iowa State College. In addition, data obtained from the earlier tryouts were included whenever the particular item remained unchanged in both earlier and final tryout forms. The total number of responses, therefore, varies for individual items.

The data are presented in two tables, for Tryout Form A (75 items) and Tryout Form B (90 items). These forms contain the same items used in the final tryouts, although individual tryout groups did not take all of the items contained in these two forms. Each table lists the item number, number of examinees selecting response A, B, C, D, or E, the number omitting the item, and the total number of examinees attempting the item. In each case the response intended as correct is underlined.

The final form of the test was developed from the tryout forms after revision based on tryout data and critics' review. The data reported here apply only to the tryout forms.

# TRUCKOUT FORM A

| Item No. | A          | B          | C          | D          | E          | Omit | Total | Item No. | A          | B          | C          | D          | E          | Omit | Total |
|----------|------------|------------|------------|------------|------------|------|-------|----------|------------|------------|------------|------------|------------|------|-------|
| 1        | <u>119</u> | 19         | 1          | 4          | 7          | 47   | 197   | 39       | 32         | 46         | <u>53</u>  | 7          | 12         | 5    | 155   |
| 2        | <u>14</u>  | <u>14</u>  | <u>40</u>  | <u>44</u>  | 11         | 63   | 186   | 40       | 8          | <u>37</u>  | <u>84</u>  | 3          | 17         | 3    | 152   |
| 3        | 11         | 9          | 36         | <u>26</u>  | 12         | 89   | 183   | 41       | 16         | <u>97</u>  | 20         | 7          | 6          | 4    | 150   |
| 4        | <u>21</u>  | 12         | 15         | 31         | 11         | 95   | 185   | 42       | 0          | 11         | 6          | 11         | <u>114</u> | 6    | 148   |
| 5        | <u>13</u>  | 29         | 11         | 10         | <u>36</u>  | 81   | 180   | 43       | 0          | 4          | <u>48</u>  | 1          | 91         | 1    | 145   |
| 6        | 6          | 46         | 33         | 16         | <u>77</u>  | 4    | 182   | 44       | 1          | 4          | 4          | <u>99</u>  | 26         | 5    | 139   |
| 7        | <u>78</u>  | 50         | 32         | 13         |            | 3    | 176   | 45       | 2          | 16         | <u>153</u> | 4          | 0          | 5    | 180   |
| 8        | <u>14</u>  | <u>110</u> | 16         | 2          | 9          | 24   | 175   | 46       | 9          | 11         | 26         | 20         | <u>109</u> | 4    | 179   |
| 9        | 30         | 21         | 4          | 3          | <u>108</u> | 4    | 170   | 47       | 1          | 8          | 24         | <u>141</u> | 5          | 1    | 180   |
| 10       | <u>75</u>  | 29         | 8          | 2          | 47         | 5    | 166   | 48       | <u>44</u>  | 16         | 25         | 74         | <u>144</u> | 10   | 213   |
| 11       | 13         | 2          | 6          | 23         | <u>111</u> | 9    | 164   | 49       | <u>44</u>  | 19         | 15         | 61         | 55         | 15   | 209   |
| 12       | 39         | 40         | <u>53</u>  | 10         | 11         | 10   | 163   | 50       | <u>62</u>  | 22         | 27         | 25         | 24         | 12   | 172   |
| 13       | 20         | 8          | 29         | <u>70</u>  | 16         | 17   | 160   | 51       | <u>97</u>  | 59         | 31         | 9          | 4          | 3    | 203   |
| 14       | 9          | 60         | 19         | <u>20</u>  | 15         | 28   | 160   | 52       | <u>103</u> | 10         | 10         | 33         | 28         | 9    | 193   |
| 15       | 1          | 10         | 8          | <u>130</u> | 5          | 5    | 159   | 53       | 64         | 4          | <u>18</u>  | 26         | 32         | 17   | 161   |
| 16       | 2          | 1          | <u>137</u> | 5          | 1          | 10   | 156   | 54       | 10         | <u>135</u> | 23         | 1          | 22         | 6    | 197   |
| 17       | 7          | <u>54</u>  | 46         | 10         | 12         | 26   | 155   | 55       | 40         | <u>48</u>  | 19         | 23         | 25         | 6    | 161   |
| 18       | 5          | 24         | 8          | 8          | <u>82</u>  | 28   | 155   | 56       | <u>78</u>  | 33         | 8          | 14         | 9          | 7    | 154   |
| 19       | 8          | 6          | 7          | 17         | <u>98</u>  | 16   | 152   | 57       | 7          | 10         | 12         | <u>129</u> | 26         | 3    | 187   |
| 20       | 0          | 8          | 4          | <u>121</u> | 11         | 8    | 152   | 58       | 5          | 2          | <u>78</u>  | 46         | 18         | 2    | 151   |
| 21       | 22         | 12         | 12         | <u>67</u>  | 35         | 4    | 152   | 59       | <u>59</u>  | 17         | 65         | 1          | 0          | 2    | 144   |
| 22       | 0          | 5          | 9          | <u>100</u> | 29         | 4    | 147   | 60       | <u>66</u>  | 1          | 12         | 58         | 32         | 2    | 171   |
| 23       | 1          | <u>146</u> | 5          | 5          | 24         | 11   | 192   | 61       | 33         | <u>17</u>  | 13         | 66         | 15         | 3    | 167   |
| 24       | 4          | 27         | <u>60</u>  | 21         | 64         | 13   | 189   | 62       | 5          | 11         | 2          | <u>78</u>  | 40         | 1    | 137   |
| 25       | <u>99</u>  | 24         | 16         | 4          | 52         | 12   | 207   | 63       | 1          | 7          | <u>38</u>  | 10         | 7          | 0    | 63    |
| 26       | 30         | 5          | 19         | 2          | <u>117</u> | 11   | 184   | 64       | 16         | 20         | 8          | <u>15</u>  | 4          | 0    | 63    |
| 27       | <u>93</u>  | 4          | 28         | 20         | 12         | 22   | 179   | 65       | <u>25</u>  | 18         | 4          | 2          | 4          | 0    | 63    |
| 28       | 23         | 51         | 23         | <u>53</u>  | 12         | 17   | 179   | 66       | 2          | 4          | 13         | <u>29</u>  | 15         | 0    | 63    |
| 29       | 18         | 10         | 15         | <u>98</u>  | 26         | 0    | 176   | 67       | 15         | <u>7</u>   | 6          | 6          | 29         | 0    | 63    |
| 30       | 10         | 15         | 57         | <u>44</u>  | 33         | 9    | 168   | 68       | 3          | 4          | <u>52</u>  | 0          | 3          | 0    | 62    |
| 31       | <u>53</u>  | 75         | 8          | 7          | 16         | 8    | 167   | 69       | <u>39</u>  | 10         | 1          | 8          | 3          | 0    | 61    |
| 32       | 5          | 6          | 20         | <u>105</u> | 22         | 8    | 166   | 70       | 17         | 0          | 22         | <u>17</u>  | 5          | 0    | 61    |
| 33       | 5          | 19         | 14         | <u>72</u>  | 45         | 10   | 165   | 71       | 19         | <u>33</u>  | 4          | 1          | 3          | 1    | 61    |
| 34       | 6          | 1          | 6          | 5          | 137        | 9    | 164   | 72       | 7          | 2          | 12         | <u>18</u>  | 21         | 1    | 61    |
| 35       | 24         | <u>89</u>  | 4          | 30         | 4          | 13   | 164   | 73       | 3          | 4          | 11         | 1          | <u>42</u>  | 0    | 61    |
| 36       | 5          | 3          | <u>111</u> | 30         | 9          | 4    | 162   | 74       | 28         | 8          | <u>14</u>  | 2          | 9          | 0    | 61    |
| 37       | <u>60</u>  | 28         | 9          | 47         | 9          | 7    | 160   | 75       | 23         | 28         | 8          | 0          | <u>1</u>   | 1    | 61    |
| 38       | <u>70</u>  | 23         | 26         | 15         | 9          | 12   | 155   |          |            |            |            |            |            |      |       |

INPUT FORM B

| Item no. | A   | B   | C  | D  | E   | Omit | Total | Item no. | A  | B   | C   | D  | E   | Omit | Total |
|----------|-----|-----|----|----|-----|------|-------|----------|----|-----|-----|----|-----|------|-------|
| 1        | 4   | 13  | 39 | 32 | 77  | 4    | 169   | 46       | 4  | 2   | 35  | 16 | 5   | 0    | 62    |
| 2        | 7   | 55  | 2  | 19 | 62  | 4    | 149   | 47       | 0  | 0   | 0   | 13 | 48  | 1    | 62    |
| 3        | 6   | 61  | 17 | 67 | 8   | 9    | 168   | 48       | 3  | 13  | 11  | 10 | 25  | 0    | 62    |
| 4        | 74  | 38  | 19 | 6  | 23  | 4    | 164   | 49       | 6  | 119 | 2   | 3  | 2   | 0    | 62    |
| 5        | 101 | 6   | 10 | 43 | 1   | 5    | 166   | 50       | 6  | 2   | 45  | 9  | 0   | 0    | 62    |
| 6        | 2   | 0   | 88 | 16 | 22  | 8    | 166   | 51       | 8  | 1   | 3   | 50 | 0   | 0    | 62    |
| 7        | 9   | 14  | 4  | 33 | 101 | 3    | 164   | 52       | 2  | 2   | 56  | 1  | 1   | 0    | 62    |
| 8        | 12  | 122 | 19 | 0  | 9   | 0    | 162   | 53       | 5  | 33  | 22  | 0  | 2   | 0    | 62    |
| 9        | 13  | 76  | 27 | 7  | 7   | 5    | 137   | 54       | 5  | 6   | 36  | 2  | 12  | 1    | 62    |
| 10       | 0   | 0   | 18 | 88 | 24  | 6    | 136   | 55       | 1  | 9   | 2   | 6  | 45  | 0    | 63    |
| 11       | 11  | 1   | 63 | 26 | 49  | 6    | 156   | 56       | 0  | 119 | 3   | 6  | 4   | 0    | 62    |
| 12       | 19  | 10  | 86 | 1  | 9   | 8    | 133   | 57       | 4  | 36  | 0   | 16 | 5   | 0    | 61    |
| 13       | 4   | 137 | 4  | 2  | 1   | 0    | 148   | 58       | 1  | 7   | 16  | 28 | 9   | 0    | 61    |
| 14       | 104 | 12  | 5  | 3  | 7   | 0    | 131   | 59       | 0  | 1   | 14  | 8  | 67  | 0    | 90    |
| 15       | 2   | 3   | 44 | 3  | 95  | 0    | 147   | 60       | 6  | 113 | 3   | 5  | 4   | 0    | 61    |
| 16       | 3   | 8   | 78 | 5  | 48  | 0    | 142   | 61       | 1  | 18  | 65  | 1  | 3   | 0    | 98    |
| 17       | 6   | 7   | 69 | 35 | 25  | 2    | 144   | 62       | 40 | 36  | 4   | 5  | 2   | 0    | 87    |
| 18       | 3   | 7   | 57 | 27 | 48  | 1    | 143   | 63       | 0  | 13  | 40  | 7  | 2   | 0    | 62    |
| 19       | 29  | 4   | 92 | 5  | 13  | 0    | 143   | 64       | 21 | 12  | 1   | 4  | 118 | 1    | 87    |
| 20       | 2   | 90  | 8  | 9  | 14  | 2    | 125   | 65       | 51 | 2   | 2   | 5  | 1   | 0    | 61    |
| 21       | 123 | 8   | 2  | 2  | 2   | 5    | 142   | 66       | 0  | 1   | 9   | 51 | 1   | 0    | 62    |
| 22       | 2   | 4   | 1  | 1  | 55  | 0    | 63    | 67       | 6  | 2   | 21  | 29 | 4   | 0    | 62    |
| 23       | 11  | 14  | 1  | 2  | 33  | 1    | 62    | 68       | 28 | 31  | 1   | 0  | 0   | 1    | 61    |
| 24       | 10  | 7   | 31 | 7  | 7   | 0    | 62    | 69       | 1  | 7   | 7   | 62 | 3   | 0    | 80    |
| 25       | 1   | 11  | 25 | 9  | 16  | 0    | 62    | 70       | 10 | 5   | 15  | 31 |     | 0    | 61    |
| 26       | 9   | 2   | 19 | 11 | 51  | 0    | 92    | 71       | 2  | 6   | 5   | 41 | 6   | 0    | 60    |
| 27       | 3   | 1   | 3  | 0  | 55  | 0    | 62    | 72       | 6  | 19  | 6   | 2  | 45  | 0    | 78    |
| 28       | 3   | 52  | 3  | 2  | 2   | 0    | 62    | 73       | 15 | 18  | 15  | 9  | 20  | 1    | 78    |
| 29       | 5   | 28  | 45 | 1  | 12  | 0    | 91    | 74       | 25 | 1   | 32  | 1  | 0   | 0    | 59    |
| 30       | 0   | 54  | 1  | 7  | 0   | 0    | 62    | 75       | 0  | 1   | 1   | 11 | 44  | 2    | 59    |
| 31       | 12  | 8   | 8  | 43 | 10  | 1    | 82    | 76       | 5  | 7   | 22  | 52 | 29  | 1    | 116   |
| 32       | 3   | 9   | 45 | 2  | 3   | 0    | 62    | 77       | 64 | 26  | 15  | 4  | 5   | 1    | 114   |
| 33       | 36  | 12  | 4  | 2  | 8   | 0    | 62    | 78       | 3  | 2   | 11  | 31 | 67  | 1    | 115   |
| 34       | 0   | 52  | 2  | 7  | 1   | 0    | 62    | 79       | 9  | 3   | 6   | 54 | 42  | 1    | 115   |
| 35       | 10  | 5   | 18 | 4  | 26  | 0    | 63    | 80       | 2  | 3   | 33  | 55 | 21  | 1    | 115   |
| 36       | 86  | 0   | 2  | 0  | 1   | 0    | 89    | 81       | 0  | 0   | 102 | 0  | 12  | 0    | 114   |
| 37       | 2   | 6   | 10 | 2  | 42  | 0    | 62    | 82       | 25 | 2   | 74  | 1  | 12  | 0    | 114   |
| 38       | 4   | 9   | 7  | 53 | 7   | 1    | 81    | 83       | 3  | 21  | 7   | 67 | 16  | 0    | 114   |
| 39       | 2   | 1   | 7  | 3  | 48  | 1    | 62    | 84       | 5  | 98  | 4   | 1  | 5   | 1    | 114   |
| 40       | 28  | 4   | 10 | 18 | 2   | 0    | 62    | 85       | 6  | 20  | 4   | 12 | 71  | 1    | 114   |
| 41       | 2   | 1   | 52 | 1  | 6   | 0    | 62    | 86       | 8  | 73  | 12  | 10 | 8   | 3    | 114   |
| 42       | 15  | 11  | 13 | 22 | 2   | 0    | 63    | 87       | 11 | 42  | 7   | 13 | 39  | 2    | 114   |
| 43       | 2   | 0   | 13 | 46 | 1   | 0    | 62    | 88       | 7  | 32  | 6   | 19 | 48  | 2    | 114   |
| 44       | 5   | 0   | 39 | 7  | 10  | 1    | 62    | 89       | 3  | 77  | 8   | 18 | 8   | 1    | 115   |
| 45       | 0   | 47  | 6  | 5  | 4   | 0    | 62    | 90       | 33 | 5   | 4   | 44 | 28  | 0    | 114   |